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# ARTILLERY ENGAGEMENT SIMULATION


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SIMULATION SYSTEMS TECHNICAL AREA

U. S. Army
Research Institute for the Behavioral and Social Sciences

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A system was developed to integrate artillery units into engagement simulation (REALTRAIN, MILES) field training. The system involved computing the impact point of artillery rounds from the data placed on the sights of the howitzers. This allowed realistic "marking" of simulated missions in the vicinity of maneuver troops. During a development test, an artillery battery "fired" 36 simulated missions. The battery improved its speed and accuracy while reducing its performance variability.

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Participating artillerymen were enthusiastic and felt they had learned a great deal, indicating that the system was an effective training method in itself as well as a compatible component of overall combat field training. A draft training circular designed to be used by training managers of direct support artillery battalions is being produced as a result of this project.

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Engagement Simulation

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## FOREWORD

Current Army Training and Evaluation Programs (ARTEP) for combat units do not adequately simulate the tactical battlefield environment. Engagement simulation techniques provide the missing element. These techniques, such as MILES and REALTRAIN, are being developed by the Simulation Systems Technical Area of the Army Research Institute for the Behavioral and Social Sciences (ARI), in response to requirements of the Army Training and Doctrine Command (TRADOC) and in coordination with the TRADOC System Manager for Tactical Engagement Simulation (TSM-TES). Engagement simulation methods have been developed for combined arms training for infantry, armor, and antiarmor units. Systems have also been developed for air defense and aviation, but until now artillery was not simulated realistically. This report describes preliminary testing of indirect fire simulation (IDFS) techniques to add realistic field artillery support.

This research was requested by and supported by the Field Artillery School, Fort Sill, Okla. It was conducted under Army Projects 2Q163743A773, FY 79 Work Program, and 2O163744A795, FY 80, with the assistance of the Human Sciences Research Corporation under Contract MDA903-79-C-0266.

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ARTILLERY ENGAGEMENT SIMULATION

## BRIEF

### Requirement:

To develop and evaluate a method for incorporating the field artillery battery into engagement simulation (ES) training exercises. Artillery fire in ES exercises is currently simulated by delivering artillery simulators to the place the maneuver commander requests. Artillerymen do not get useful training from this, and troop commanders develop unrealistic expectations of the responsiveness and accuracy of direct support artillery units.

### Procedure:

By determining the data actually set on a gun after a simulated (dry) firing, the corresponding point of impact could be calculated and the artillery simulator be placed at the point where a round would land if live ammunition were used. A communications system was developed to integrate the artillery system--Forward Observer, Fire Direction Center, and guns--with the artillery engagement simulation (ARES) system--a Chief Artillery Controller, fire markers to place the simulators, gun controllers to observe the data on the gun, and a Fire Marker Control Center to calculate the burst locations.

A full-scale developmental test October 1979 exercised the control system by simulating 36 missions from a 155mm howitzer in response to calls and feedback from a forward observer. Each mission began at the initial request for fire and continued until the forward observer reported that the target had been hit.

### Findings:

Over the 36 missions, the artillery battery improved its speed, accuracy, and consistency of performance. The participating artillerymen were enthusiastic and felt they had learned a great deal, indicating that the system was an effective training method in itself. Development of the system should continue, both to validate the ARES with actual maneuver troops and to extend the method to other indirect fire such as mortars.

### Utilization of findings:

The artillery engagement simulation system developed here is compatible with both moderate fidelity training (REALTRAIN) and the high fidelity system soon to be fielded (MILES). The training procedures allow artillery units to become full partners in an overall combat training system which encourages learning in as realistic training environment as possible.

A draft training circular, designed for use by training managers of direct support artillery battalions, is being published separately.

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# CHAPTER I

# INTRODUCTION

## Background

Collective tactical training of maneuver units has been dramatically affected in recent years by the introduction and continued refinement of a training method known as engagement simulation (ES). Like other field training exercise (FTX) methods, an ES exercise starts with the two opposing units. The difference is in what drives the development and outcome of the exercise. In any other form of FTX, the outcome is determined either by the judgment of umpires as to what would have happened if real ammunition had been used or by a scenario or plan which dictates the outcome in order to structure certain types of operations or bring out certain training objectives. The central feature of an ES exercise is that the outcome is determined by the actual behaviors of participating individuals and units. The losers live to learn from the experience. The ES method, an exercise coupled with an after action review that concentrates on learning through a participatory discussion of the exercise, has been shown to be significantly more effective than other training methods in developing a unit's ability to accomplish its mission and minimize casualties.[1]

The essential characteristic of ES is believable, near real-time casualty assessment. In the present method, known as REALTRAIN,[2] this is provided by controllers with the tactical element on both sides, down to the fire team or combat vehicle. The heavy requirement for control personnel has limited its use to units no larger than the company team and, more commonly, to the platoon and squad. A more technologically advanced system employing eye-safe lasers automatically assesses the casualties for direct fire weapons and will be fielded toward the end of FY80. This advanced system, the Multiple Integrated Laser Engagement System (MILES), will greatly reduce some of the personnel requirements that has limited the use of REALTRAIN.

[1] R. Root, *et al.*, *Initial Validation of REALTRAIN with Army Combat Units in Europe*, Research Report 1191, U.S. Army Research Institute, October 1976, and L. Meliza, *et al.*, *REALTRAIN Validation for Rifle Squads II: Tactical Performance.* Research Report 1203, U.S. Army Research Institute, March 1979.

[2] TC 71-5, *REALTRAIN*, Department of the Army, January 1975.

The emphasis in the preceding discussion has been on the simulation of casualty effects from direct fire weapons. An integral part of tactical engagement simulation training, however, is the simulation of artillery and its effects. Artillery fire represents a vitally important source of firepower to the tactical commander; an ES exercise must include the opportunity for him to learn the proper employment of this combat asset.

There are five steps in the sequence of events involved in indirect fire:

(1) The forward observer (FO) or fire support team (FIST) assists maneuver elements in calling in indirect fire on the enemy;

(2) The fire direction center (FDC) processes requests from the FO or FIST and issues firing directions to the firing elements;

(3) The firing elements execute the fire mission;

(4) Artillery rounds impact on or near the enemy; and

(5) The FO/FIST adjust subsequent rounds based on observation of impacting rounds.

Artillery simulation for REALTRAIN involves onlv the first. fourth and fifth steps. Artillery simulation techniques permit the FO (or other tactical player) to call in simulated rounds and to adjust succeeding rounds on to the target. This necessitates the simulation of artillery effects–the fourth step in the chain of events. Special emphasis is required on simulating incoming indirect fire rounds, not only to provide troops on the ground with realistic, but safe, indication that they are under attack by artillery fire, but also because the FO requires feedback on the accuracy of his mission request. This simulation also provides a means for the objective assessment of casualties from artillery fire.

Simulation of the effects of artillery fire required the development of procedures for delivering simulated indirect fire rounds where thev are called for and the use of an artillery simulator to represent the "flash-bang" of an incoming round. This combination of procedures provides sufficient indication of the troops on the ground that they are being engaged by artillery and provides adequate feedback to the person requesting a given fire mission that it has been executed.

In the present artillery simulation method, the tactical fire support radio nets are used by either maneuver element leaders or forward observers to request fire from a simulated FDC. The simulated FDC translates the request for fire into instructions for controllers (fire-markers) who place artillery simulators at the location desired in near real time. Unit leaders and FO's are then able to observe the rounds and request subsequent adjustments. Thus, the leader and forward observer are required to practice the entire range of skills necessary to employ indirect fire effectively.

This simulation has been excellent, as far as it goes. However, is does not exercise any part of the artillery firing system except the forward observer. Unlike the direct fire simulation, the effectiveness of artillery simulation in an ES exercise does not depend on an artilleryman's execution of a combat task, other than the FO's. The fact that the simulators were simply placed where he asked for them, meant that the possible effects of errors or limitations in the rest of the artillery firing system were ignored and no artillerymen except the FO received useful training. When ES was limited to units below the company level, this was not a serious shortcoming, since those echelons do not fully commit an artillery unit and their leaders are not usually heavily involved in coordination with the supporting artillery.

The one exception to this is the armored cavalry platoon and the extension of ES to armored cavalry did lead to development of a method for representing the effect of a mortar section's speed and accuracy in the indirect fire simulation for that type of unit.[3] Similarly, the extension of ES to the company, and even battalion, level with MILES will increasingly involve echelons of maneuver unit command that become involved in artillery fire planning, coordination and tactical fire control. The omission of the elements that provide realism to that process therefore becomes more serious.

The opportunity for training of the firing unit also increases in direct proportion to the size of the maneuver units. A battery supporting an exercise employing two maneuver platoons would not be sufficiently committed for realistic unit training. A battery supporting an exercise containing two company teams, however, would be committed to the same extent that is would be if supporting a maneuver battalion with two companies on line. It can expect to be used at a realistic level and have realistic performance requirements placed on it.

[3]Exequiel R. Sevilla, Jr., *Engagement Simulation Training Techniques: Indirect Fire Simulation Procedures,* Research Product 79-3, U.S. Army Research Institute, January 1979.

Two goals related to the incorporation of the entire artillery firing system into the ES exercise have been identified. One is teaching the maneuver commanders and fire support planners to work with the real capabilities and limitations of their fire support system. The other is to provide realistic training at all levels of the fire support system. The present research was undertaken to meet these goals.

The specification of the requirements for the training system must be based on the goals just stated. The training system must be able to do essentially the same thing that the direct fire simulation does; i.e., determine what would have happened if real ammunition had been used and assess casualties accordingly. It must do it in near real time, with a minimum of additional resources, and provide for recovery of information for feedback and diagnosis of training needs.

If the indirect fire simulation system is to incorporate the battery into an ES exercise, it must (1) find out what data were on the howitzer and ammunition when firing was simulated, (2) determine where the effect of that fire would have been located, (3) cause that effect to be simulated and casualties to be assessed, and (4) keep the necessary records to support both subsequent learning by the participants, and diagnosis by the training managers. This report will describe the research conducted and the system developed to accomplish those tasks.

## CHAPTER II

## DESCRIPTION OF AN ARTILLERY ENGAGEMENT SIMULATION (ARES) TECHNIQUE

### General

This chapter will describe the manner in which the research had led to development of an artillery engagement simulation (ARES) technique, and summarize the procedures, personnel and equipment involved.

### Development of ARES Procedures

Methods for indirect fire simulation have grown out of two existing sets of procedures. One set was developed to support SCOPES and REALTRAIN exercises. These procedures involved directing a fire marker to a specific location on which fire had been requested by an FO or FIST. The other set was the technical fire direction technique known as "replot" by which target coordinates were accurately plotted in FDC from the firing data that did hit the target. These existing sets of procedures were combined and augmented using resources that were readily available to the standard firing unit. The procedures to be developed could not impose an unreasonable delay on maneuver. It had to be an accurate reflection of what the artillery firing system actually did, yet be functionally independent of it. Finally, the procedures had to produce performance information for feedback and diagnosis of training needs, in order to have a complete training system.

It was immediately apparent that in adapting the two existing procedures – fire marking and replot – to the criteria just stated, a number of questions would arise. To reflect accurately where the battery's rounds would have actually gone, the data used in the replot computations should be collected from the howitzer that simulated firing the round. The requirement for highly skilled or supervisory personnel had to be minimized, yet checking of data on a gun has usually been the job of an officer or senior NCO. The question was raised, therefore, as to what lower rank could check the howitzer settings accurately and also be accepted by the gun crew as a fair, impartial observer. How much interference would he cause?

Also, replot requires a well-trained fire direction specialist, is usually done in an FDC team environment, and is usually not done against time. What is the effect of one man doing it independently, out of the FDC, under time pressure? Could a less demanding method be developed which would also provide some means of checking accuracy? What procedure would best facilitate rapid, accurate land navigation? Finally, what system of control and communications could best tie these elements together into a working system?

The ability of soldiers with the minimum possible qualifications (Cannoneers, Grade E-1, who had just completed AIT) to perform the gun controller tasks was verified in tests at Fort Sill in June 1979 (Appendix A). At the same time, simplified methods of computing impact coordinates from the data (charge, deflection, quadrant elevation) set on the howitzers were developed. One method used the hand-held programmable calculator available to all artillery units. The other method was a modification of the manual replot technique.

Having demonstrated that the gun data recovery and grid impact location tasks could, at least technically, be accomplished in an acceptable manner, the research staff then developed procedures for an artillery simulation system which was expected to provide answers to the remaining questions. A developmental test to investigate the extent to which the system did, in fact, satisfactorily answer these questions was then designed (Appendix B) and conducted in October 1979. The results of this developmental test are presented in Chapter III. The system that has emerged from this research is described in the following paragraphs.

## Summary of ARES

### Elements of the Control System

The control system consists of a Chief Artillery Controller (CAC), fire markers, gun controllers, and a Fire Marker Control Center (FMCC) which includes fire marker control personnel who calculate the burst locations, and a fire marker control center chief. The interactions of these personnel in the operation of the system are described below and illustrated in Figure 1.

Steps in processing a call for fire are:

(1) The FIST originates calls for fire in response to the tactical situation. This is transmitted over the tactical fire request net in accordance with unit tactical Standard Operating Procedure (SOP).

(2) The FDC prepares and transmits firing data to the howitzers.

(3) The gun crew places the data on the howitzer and simulates firing.

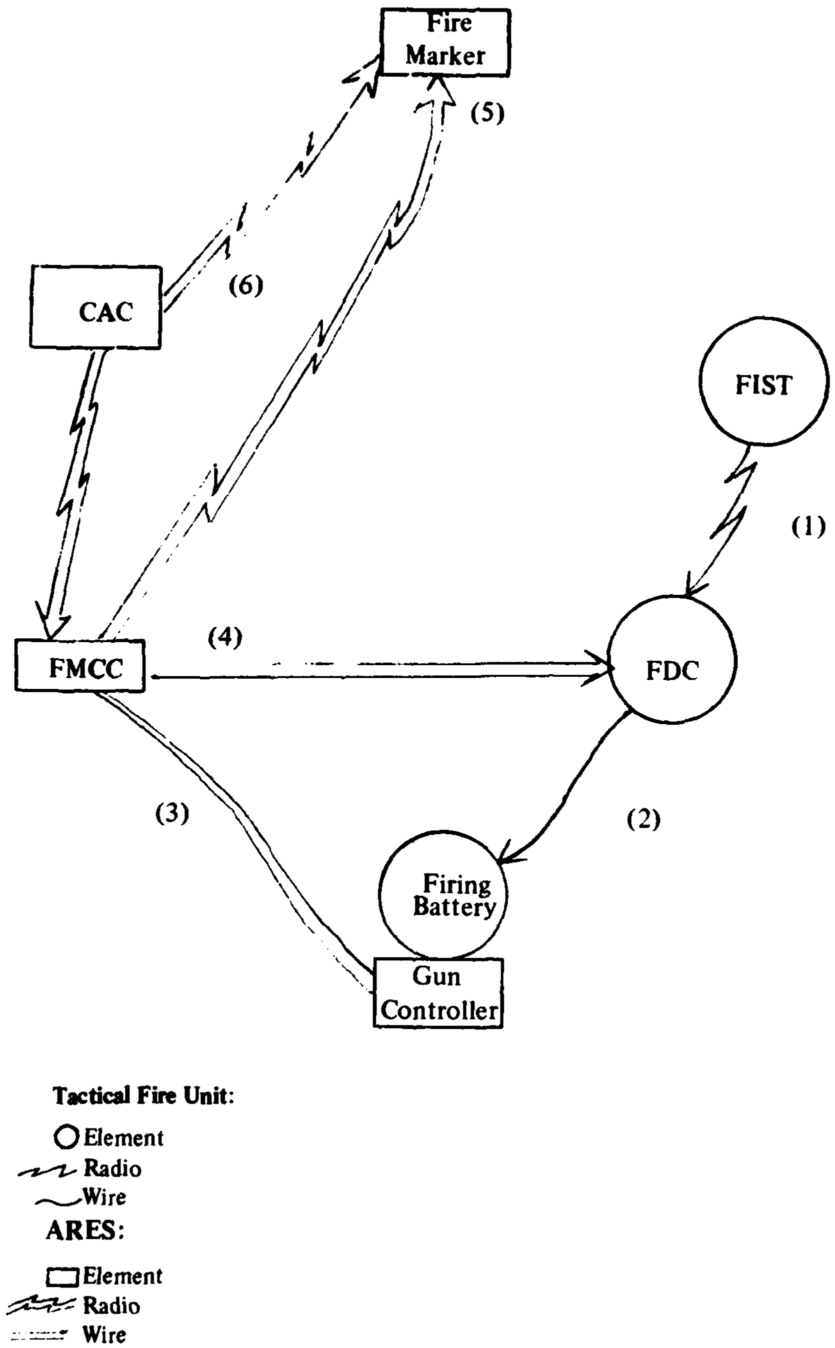
(4) Gun controller observes settings that were actually on the howitzer, the dummy fuze setting and charge prepared and transmits them to the Fire Marker Control Center (FMCC).

(5) Personnel in the FMCC determine where the rounds with the settings reported by the gun controller, would have landed, then prepare and transmit instructions to the fire marker.

(6) A fire marker places a simulator in accordance with FMCC instructions. If troops are at the location marked, he advises the maneuver controller with them of the type of fire delivered. The maneuver controller then assesses casualties in accordance with established criteria. (If there is no maneuver controller with the troops, the fire marker assesses casualties.)

(7) Fire marker reports effect of fire to FMCC. This report is monitored by the CAC. FMCC records effect. At the end of each mission, CAC directs fire marker to appropriate reference point to support continued action.

**Figure 1**
**Elements of ARES in Operation with a Tactical Fire Unit**



**Chief Artillery Controller***

- **Responsibility and Authority**: Responsible to Exercise Director for effective operation of the ARES. Has directive authority over all personnel in ARES.

- **Numbers**: One per exercise.

- **Qualifications**: LT or SFC, Fire Support Officer FIST leader or MOS 13F, Fire Support Coordination Specialist.

- **Duties**:

  - Insure that all ARES personnel are properly trained and equipped to perform their duties.

  - Supervise preparation of area for indirect fire simulation, to include selection of reference points, location of FMCC and arrangements for controller wire and radio nets.

  - Direct ARES personnel during exercises, particularly the pre-positioning of fire markers to facilitate rapid marking.

  - Prepare summary of indirect fire play of exercise for use in AAR and critique to firing battery.

- **Equipment**: ¼-ton truck with 2-channel radio capability.

**Fire Marker Control Chief**

- **Responsibility and Authority**: Responsible to CAC for proper functioning of the FMCC. Supervises Fire Marker Control Computers, and the gun controllers.

- **Numbers**: One per exercise.

- **Qualifications**: SSG or SGT, MOS 13E, Fire Direction Specialist.

*These duties were performed in the test by a member of the research staff and the information presented below is based on his experience and observation.

- **Duties**:

  - Insure that Fire Marker Control Computers are properly trained and equipped to perform their duties.

  - Insure that FMCC is set up and operational, to include necessary radio communications and wire to FDC and guns.

  - Supervise operation of FMCC during exercise.

  - Issue marking instructions to Fire Markers.

  - Direct gun controller as to piece to check.

- **FMCC Equipment**: M577 or suitable shelter with three channel radio capability, two telephones and wire.

**Fire Marker Controllers**

- **Responsibility**: Responsible to Fire Marker Control Center Chief for correct computation of impact locations, fire marker instructions and maintenance of computer record.

- **Numbers**: Two per exercise.

- **Qualifications**: E 3/4, MOS 13E, Fire Direction Specialist.

- **Duties**:

  - Assist in establishing FMCC as directed by FMCC Chief.

  - Compute directions for fire markers based on data from gun controllers.

  - Maintain computer records.

- **Equipment**:

  - Hand-held programmable calculator, model TI-59 and/or manual FDC equipment to perform replot.

  - 1/25000, UTM gridded map of exercise area or 1/25000 grid sheet and 1/50000 map.

  - Computer records.

**Gun Controllers**

- **Responsibility**: Responsible to Fire Marker Control Center Chief for accurate observation and reporting of settings at time of dry firing.

- **Numbers**: Minimum of two per exercise, three per exercise preferred.

- **Qualifications**: SGT or SP4, MOS 13B, Cannoneer. (Must have experience as gunner on weapon to be controlled.)

- **Duties**:

  - Insure that wire line is installed from guns to FMCC.

  - Check weapon and sight for operability.

  - Determine and report data fired to FMCC.

- **Equipment**: Telephone and wire, gunner's quadrant.

**Fire Marker**

- **Responsibility**: Responsible to CAC for prompt, accurate marking of fires as directed by FMCC.

- **Numbers**: Minimum of two per exercise. (As a rule of thumb, there should be enough so that no place in the maneuver lanes will be more than two minutes away from one.)

- **Qualifications**: SGT, MOS 13F, Fire Support Coordination Specialist, or any soldier with high skills in land navigation, e.g., MOS 82C, Survey Specialist.

- **Duties**:

  - Occupy reference points as directed by CAC.

  - Mark fires as directed by FMCC Chief.

  - In the absence of a maneuver controller, assess casualties in accordance with effectiveness criteria.

  - Report effect of fires to FMCC.

- **Equipment:**

  - AN/PRC-77 radio.

  - Lensatic compass.

  - ¼-ton truck with one channel radio capability.

  - Artillery burst and smoke simulators.

  - MILES Controller Gun.

# CHAPTER III
# ARES DEVELOPMENTAL TEST

## General

This chapter describes the developmental test which was conducted to demonstrate the feasibility and training value of the proposed ARES. The test design plan is at Annex B. Execution of the test was preceded by a training phase as shown at Annex C.

## Method

### Tactical Setting

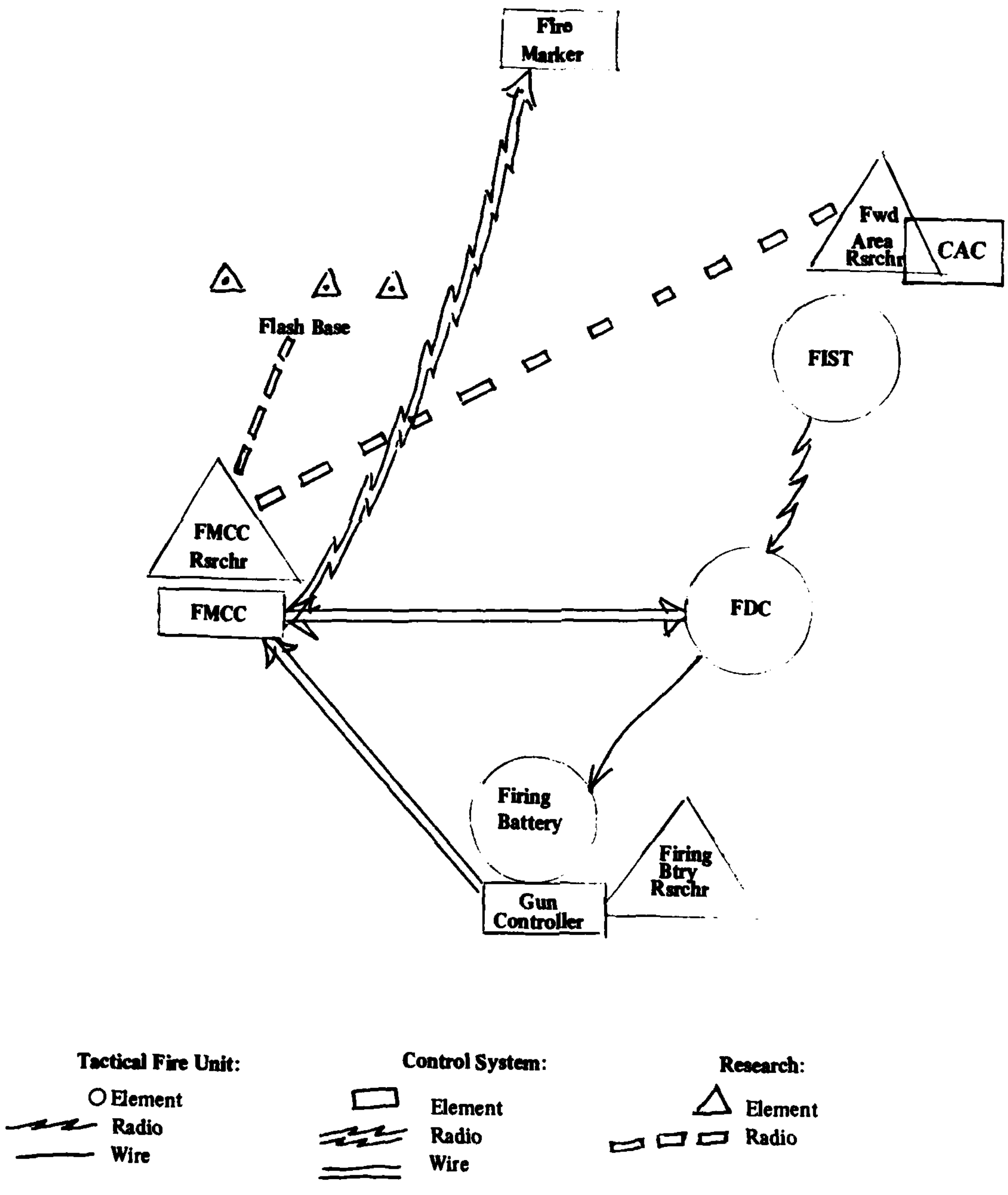
The general setting was that of a battery providing fire support to a company level ES exercise. The ES exercise itself was simulated with a member of the research staff acting as the supported unit commander/Chief Artillery Controller and providing tactical situations to a FIST. The FIST was required to react to these situations, and to send fire plans and fire requests to the firing battery, which then "dry fired" them. The ARES then processed these fire missions, i.e., checked howitzer data, computed impact location and placed simulator in impact point.

### Research Setting

The research staff gathered data as to the speed and accuracy of both the artillery system and the ARES. An artillery survey team (known as a flash base") located the points where the fire marker actually placed their simulators. Opinions and perceptions of the troops were sampled before, during and after the series of exercises. The integration of the artillery system, ARES and research staff is shown in Figure 2.

**Figure 2**

**Integration of Research Structure, ARES and Tactical Fire Unit**



## Personnel

The unit consisted of a battery of a direct support artillery battalion (155mm Howitzer, SP, M109A1) and a Fire Support Team (FIST) from the HQ battery of that battalion. The battalion had full TO&E equipment and a high priority readiness mission. It was, however, substantially below its authorized strength and grade levels and, due to conflicting training support requirements, the battery had not operated in the field as a firing battery for several months. The battery commander had only recently assumed command and this was his first opportunity to command the battery in the field.

### The ARES

A retired Marine Corps artillery officer, who was a member of the research team, served as the CAC. The three gun controllers were an E-5, an E-4, and an E-3 designated by the battery commander in response to a request for three representative cannoneers. They were technically competent to the level of gunner (the E-5 to the level of Chief of Section). The three Fire Marker Control Center Personnel were drawn from the battalion FDC section. The chief was an E-6, the battalion chief computer. The two computers were an E-3 and E-2 from his section. The E-3's experience was as a chart operator but he also performed duties as a computer in the exercise. The E-2 normal duty was as a computer at which he was proficient. The two fire markers were both E-5s, fire support coordinators, and were assisted by two E-3 drivers. Both were proficient in their MOS.

To check the accuracy of the firemarkers, a flash base of three observation posts and a plotting central, manned by the battalion survey section, were set up in the forward area.

## Scenario

The scenario to which the FIST responded was designed to present a representative array of situations and missions that would be encountered in a typical ES exercise. The first two days of exercises consisted of an initial attack situation, then, after capturing the objective,

a simulated counterattack occurred presenting a defensive situation. The notional exercise force then attacked back across the exercise area on the third day.

Prior to each phase of the exercise, the FIST leader was given the order for the next phase and tasked to prepare a fire plan, as a company team commander would have tasked him. A sample order is at Appendix D. The fire plan concentrations were then plotted by the battery. The FIST then moved through the exercise area as if it was supporting a maneuver unit in an ES exercise. The CAC developed the scenario for the FIST personnel, described the hypothetical tactical situation and identified the targets. The FIST members then responded with appropriate fire missions. The missions and situations were structured to result in the firing of a total of 36 missions as shown in Table 1.

**Table 1. Types of Missions Fired in Exercise**

| | Ammunition | | Adjustment | | Totals |
|---|---|---|---|---|---|
| | HE | Smoke | Adjust fire | Fire for effect | |
| **Preplanned** | 3 | 1 | 24 | 4 | 4 |
| **Tgt. of Opportunity** | 26 | 4 | | 6 | 30 |
| **Final Protective Fire** | 1 | | | 1 | 1 |
| **Preparation** | 1 | | | 1 | 1 |
| **Totals** | 31 | 5 | 24 | 12 | 36 |

**Terrain and Weather**

The exercise lane was about 1½ km long and lay across a shallow valley between two ridges, each about 20 meters higher than the floor of the valley and about one kilometer apart. Overall slopes were quite gentle but they were heavily eroded with many gullies from three to ten feet deep, which were significant obstacles. A swamp and two small lakes occupied the center of the valley. Vegetation consisted of grass, waist-high shrubs, and isolated stands of trees. The battery occupied two positions at ranges of about 6000 to 8000 meters from the center of the exercise lane. The weather was clear, cool and dry throughout the exercise period.

**Figure 3**

**Sequence of Events in a Mission and Communication Traffic**

| Observer–FDC | FMCC–Fire Marker | FMCC Research–Flash Base | Gun Controller–FMCC |
|---|---|---|---|
| *Forward Area Researcher points out target to FO. FO identifies it and prepares fire request.* | | | |
| FIST: M70, this is D38, adjust fire, over<br>FDC: D38, this is M70, adjust fire, out<br><br>FIST: Grid 964 898, over<br>FDC: Grid 964 898, out<br><br>FIST: Squad in open, VT in effect, over<br>FDC: Squad in open, VT in effect, out | | | |
| *FDC computes mission and sends it to guns who simulate firing it.* | | | |
| FDC: Shot, over<br>FIST: Shot, out | | | Deflection 3182 quadrant 311*.<br>[FMCC reads back.] |
| *FMCC determines coordinates of burst location, computes and transmits instructions for fire marker.* | | | |
| | Fire Marker 1, this is Control, from RP 2, AZ 750 mils., distance 210 meters.<br><br>[Fire Marker reads back] | Flash Base Central, this is Control, observe grid 9665 8924.<br><br>[Flash Base Central reads back.] | |
| *Fire Marker marks fire. Flash base triangulates simulator burst.* | | | |
| | Control, this is Fire Marker 1. Mark. . .now.<br><br>[FMCC acknowledges] | Control, this is Flash Base Central, grid 9675 8911<br><br>[FMCC reads back] | |

*Charge, number and type of shell and fuze were standard.

## Reference Points

Five reference points from which the FMCC could generate azimuth and distance instructions for the fire markers were selected and surveyed before the exercise. These were three to four hundred meters apart along the axis of the exercise lane. The CAC positioned the two Fire Marker teams at whatever pair of reference points was best suited to the pending action.

## Sequence of Events in a Mission

Figure 3 illustrates the sequence of events in a mission. It states the events and describes the traffic between each of the elements involved.

## Data Collection

### Time Variables

The time for completion of each event was determined from the times noted by the indicated researchers for each of the indicated events. Times were synchronized on electronic stopwatches before the exercise bagan. The time variables which were measured were:

#### Artillery System

- **Observer delay time.** From either identification of the target or seeing the simulator for the previous round to transmission of target location adjustment to the FDC.

- **FDC delay time.** From receipt of fire request or adjustment from FO to initial command to guns.

- **Gun delay time.** From receipt of data at the guns to simulated firing.

- **Artillery system delay time.** The length of time it would have taken the artillery system (less ammunition handling time and time of flight) to fire the mission; i.e., from identification of the target or marking of previous shot to simulated firing of piece. This is the sum of the three previous times.

**Control System**

- **Gun controller delay time.*** From the simulated firing of the howitzer to reporting of the quadrant fired to the FMCC.

- **FMCC Delay time.** From receipt of data from the gun controllers to sending of the distance to be moved to the fire marker.

- **Fire marker delay time.** From receipt of data from the FMCC until the marking of the fire.

- **Control system delay time.** The time required to mark the round; i.e., that from simulated firing of the howitzer to marking of the round. It is the sum of the three previous times.

- **Total delay time.** The entire time to process the shot, from identification of the target or marking of previous round to marking of round. It is the sum of the artillery and control system delay times.

**Accuracy Variables**

To determine the accuracy of various elements of the artillery and control systems, the following data were recorded.

- Target location as requested by the FO.

- Discrepancies between firing data ordered by the FDC, and data reported by the gun controller.

- Impact location provided to the fire marker.

- Grid coordinates at which simulator was actually placed.

**Attitude and Opinion Data**

The following attitude and opinion data were collected:

*There were six occasions in the first 21 missions when the gun controllers were not on the assigned gun when it fired. This situation occurred only when fire for effect was ordered. The practice initially was that when fire for effect was ordered, the FMCC would direct the gun controller to a randomly selected gun. On these six occasions, the gun controller was not on the gun because he was moving between guns when the battery fired. While he was able to report data to the FMCC, delay resulted and he could not verify that the data was that which was fired. Additionally, since the timekeeper was with him, the "shot" time was lost. After mission 21, the procedure was changed. Two controllers were used with one reporting data on the adjusting howitzer. The other checked a different howitzer on each of the adjusting rounds. When fire for effect was ordered, the data of whatever howitzer he happened to be on at that round was used by the FMCC.

- A questionnaire was administered before and after the series of exercises to the FDC and firing battery personnel. This questionnaire had been pre-tested at the earlier feasibility tests at Fort Sill.

- Controllers and FIST members were interviewed by the researchers.

The Fire Marker Control Computer Records (completed sample at Appendix E) are the basic records of the ARES. They provide the record of the data received from the guns, the instructions sent to the fire marker and the identity of the fire marker assigned on each mission.

## Results

### General

In the course of the 36 missions shown in Table 1, a total of 82 firings was simulated by the battery. Data as to the speed and accuracy with which the firing was done and the effect simulated are presented in Appendix F, and summarized in Table 2 below. Questionnaires were administered to participants in accordance with ARI Regulation 70-25. Results are presented in Appendix G and summarized in Figure 4 below. Other participants were interviewed in accordance with interview guides shown in Appendix H. Responses are summarized in Tables 10-11. Operational observations are recorded in Appendix I.

### Control System Performance

The data on control system responsiveness for all firings for which valid data were recovered, are summarized in Table 2 below.

Table 2. Control System Time Data
Summary (Seconds)

| | Mean x | Standard Deviation s | Number of Observations n |
|---|---|---|---|
| Gun Controller Time | 38.14 | 25.93 | 73 |
| FMCC Time | 81.27 | 33.47 | 74 |
| Gun Controller and FMCC Time | 119.55 | 42.41 | 67 |
| Fire Marker Time (all shots) | 194.40 | 117.40 | 73 |
| 1st Shots | 240.33 | 136.19 | 30 |
| Subsequent | 162.35 | 89.21 | 43 |
| Control System Time (all shots) | 304.01 | 115.83 | 67 |
| 1st Shots | 338.44 | 135.44 | 27 |
| Subsequent | 280.78 | 93.55 | 40 |

There were twenty-four missions on which complete data were recovered for all shots. If these are divided sequentially into four blocks of six each, a pattern emerges as shown in Table 3 below.

Table 3. Median Control System Responsiveness
(Seconds) 24 Key Missions, Divided into Equal Sequential Blocks

Control System Element

| Mission Block | Gun Controllers | FMCC | Fire Markers | Overall |
|---|---|---|---|---|
| I | 31.0 | 108.0 | 216.5 | 377.0 |
| II | 28.0 | 86.0 | 177.0 | 291.0 |
| III | 31.0 | 87.5 | 247.0 | 354.0 |
| IV | 27.5 | 67.0 | 129.5 | 208.5 |

Gun controller delays appear to be minimal from the first series of missions and do not appear to change appreciably over the four mission blocks. The FMCC and the fire markers produced a smaller median delay in the second block. For the third block, the FMCC's median time did not change while the Fire Marker's became considerably slower. In the fourth block,

all system components combined to provide the smallest median system delay yet. The researchers were unable to determine why the fire marker time in the third block increased.

Because the time from receipt of instructions by a fire marker to marking of the shot was proven to be highly dependent on the distance to be traveled, the fire markers' speed (distance traveled in meters divided by time required to mark the shot in seconds) was determined for each shot. These data are shown in Tab 2 to Appendix F. The linear regression of time, t, on distance, d, was found to be: $t = 84.07 + 0.87d$, with a correlation coefficient, r, of 0.73 and a significance level of 0.01. The implication is that it took the fire markers about a minute and a half to record the data, use the compass to determine the direction and start off, they then moved at about 0.87 meter/second (1.79 mph). Due to the terrain obstacles, most missions were marked by a footmobile fire marker.

The only source of consistent inaccuracy was the fire markers. Errors were caused by the difficulty of maintaining direction and of estimating distances across and around the terrain obstacles. Fire marker error data is presented for each firing in Tab 3 to Appendix F and summarized in Table 4 below. All FMCC directions after the first round were based on the assumption that the fire marker had correctly executed his previous instructions and was therefore at the location computed for the previous round.* This is analogous to the live fire situation, wherein the FDC assumes that the round impacted where it should have, based on the FDC computations. Any corrections sent by the observer are calculated from where the previous round should have hit.

*In the absence of the flash base, which was present in this exercise only as a research aid, the FMCC would have no way of knowing whether or not the fire marker had correctly executed his previous instructions. Flash base information was therefore not used by the FMCC in directing the fire markers in this exercise.

**Table 4. Fire Marker Data***

| | Error in Meters | % Error |
|---|---|---|
| Mean Cumulative, Mission Error | 75.5 | 33.9 |
| Mean Per Shot Error, All Shots | 48.3 | 38.3 |
| 1st Shots | 69.2 | 41.4 |
| Subsequent Shots | 31.6 | 32.0 |

Another aspect of fire marker performance were the compasses used. The test design plan called for lensatic compasses. The battalion was not able to provide these and issued M-2 compasses instead. (The lensatic compass is primarily for land navigation; more easily handled but less accurate than the M-2 compass which is primarily a hasty survey instrument.) Both fire markers used M-2 compasses the first day. Fire marker 2 then expressed his preference for a lensatic compass. The Forward Area Researcher gave Fire Marker 2 his personal lensatic compass to use for the remainder of the exercise. Data in Table 5 compare the performance of the two fire markers with the two compasses.

*Table 5. Comparison of Fire Marker Performance by Day*

| | 1st Day | 2d & 3d Days |
|---|---|---|
| FM 1 | (M2 Compass) | (M2 Compass) |
| Mean Speed m/sec | 0.56 | 0.41 |
| Mean error % | 42.4 | 35.2 |
| FM 2 | (M2 Compass) | (Lensatic Compass) |
| Mean speed m/sec | 0.71 | 0.77 |
| Mean error % | 29.7 | 42.0 |

The data are not strictly comparable because each mission presented unique situations, but the differences do support an inference that fire marking was accomplished more rapidly with the lensatic compass but with less precision. Though this inference is not statistically significant in these data, it is logical considering the characteristics of the two compasses.

*Fire marker accuracy is determined by comparing the coordinates directed by the FMCC with those reported by the Flash Base. These were determined by triangulation on the flash and smoke of the simulator. Some undetermined error must be considered to exist in triangulating on such a transient, imprecise aiming point.

The FMCC transmitted only one error, when the calculator operator misread the display of distance the fire marker was to move by 100 meters. To increase accuracy, each set of firing data from the howitzers was converted to impact coordinates by two FMCC controllers working separately. One controller used the TI-59 calculator, the other did a manual solution with a firing chart. If the two solutions did not agree within 40 meters, the FMCC chief did accuracy checks to determine the error. For the 82 firings, there were 164 calculations. Six internal errors were detected, three by the calculator method and three by the manual solution.

The determination of the direction and distance of the fire marker's movement was much more accurately done by calculator than by chart. In the calculator, it was an exact mathematical determination. On the chart, it was necessary to line up a target grid (a transparent sheet with 100 meter grid squares and a 6400 mil protractor) over the two plots (fire markers and desired locations) and read the distance and azimuth from it. For the shorter moves, it was difficult to achieve a precise alignment of the target grid on a 1/25000 chart. Azimuths and distances typically varied by 50 mils and meters, respectively, from the calculator solution.

There were no incidents of gun controllers reporting data inaccurately.

**Artillery System Performance**

The data on artillery system responsiveness for all firings for which valid data was recovered are summarized in Table 6, below.

**Table 6. Summary Artillery System Time Data (Seconds)**

| | mean $\bar{x}$ | std dev s | number of observations n |
|---|---|---|---|
| All FO Times | 53.33 | 41.78 | 73 |
| 1st shots | 76.18 | 46.17 | 33 |
| subsequent | 34.47 | 25.30 | 40 |
| All FDC Times | 74.77 | 48.90 | 71 |
| 1st shots | 92.63 | 61.37 | 30 |
| subsequent | 61.71 | 31.31 | 41 |
| All Gun Times | 39.17 | 23.41 | 72 |
| 1st shots | 47.79 | 25.06 | 29 |
| subsequent | 33.35 | 20.25 | 43 |
| All Artillery System Times | 167.90 | 79.10 | 70 |
| 1st shots | 216.70 | 88.16 | 30 |
| subsequent | 131.30 | 44.64 | 40 |

These data for the Artillery System first round times, when arrayed in three equal blocks in the sequence in which they were run (Table 7, below), show an indication of a trend toward shorter delivery delays with continued training. Further, the variability between missions appears to decrease as indicated by the decreasing standard deviations.

**Table 7. Artillery System Delay for First Round Delivery for Three Equal Sequential Blocks**

| Mission Block | Mean Time (Seconds) | Standard Deviation |
|---|---|---|
| I | 251.00 | 175.86 |
| II | 222.30 | 72.42 |
| III | 179.00 | 61.44 |

The artillery system accuracy can be estimated by comparing the target location requested by the FO, with the location calculated by the FMCC. The system of checks employed in the FMCC insures that the grids computed from the gun controller data by calculator and chart agreed within 40 meters or less in all cases. Since the calculator solution is a mathematically exact one, any deviation of more than 40 meters must be due to error in the artillery system, either in the FDC gunnery solution or in the setting of the data in the howitzer. This comparison is present in Table 8.

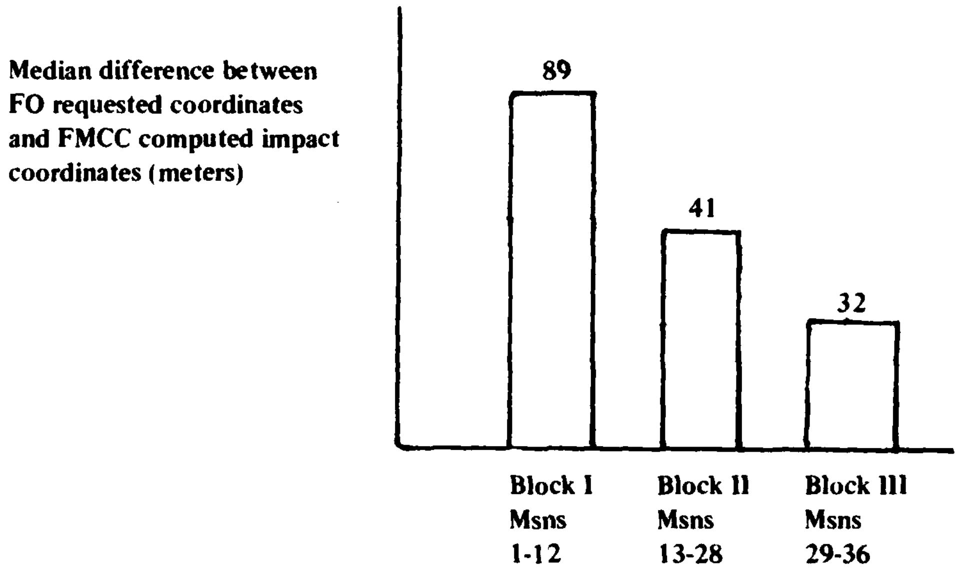
**Table 8. Difference Between FO Requested and FMCC Directed Grids (Meters)**

| Msn. No. | Difference(m) | Msn. No. | Difference(m) |
|---|---|---|---|
| 1 | 67 | 18 | 50 |
| 2 | 45 | 21 | 32 |
| 5 | 132(1) | 23 | 41 |
| 6 | 210(1) | 28 | 22 |
| 9 | 89 | 29 | 30 |
| 10 | 51 | 31 | 41 |
| 11 | 1738(2) | 32 | 228(2) |
| 12 | 456(2) | 33 | 30 |
| 13 | 41 | 34 | 30 |
| 14 | 20 | 35 | 32 |
| 16 | 45 | 36 | 50 |

(1) Error in setting gun data
(2) Error in FDC solution

A significantly favorable linear trend exists in these data ($p < 0.05$). This can also be seen by comparing the median error of three sequential blocks of the above data, as in Figure 4, below.

**Figure 4. Artillery System Accuracy, By Mission Block***




**Supporting Attitude and Opinion Data**

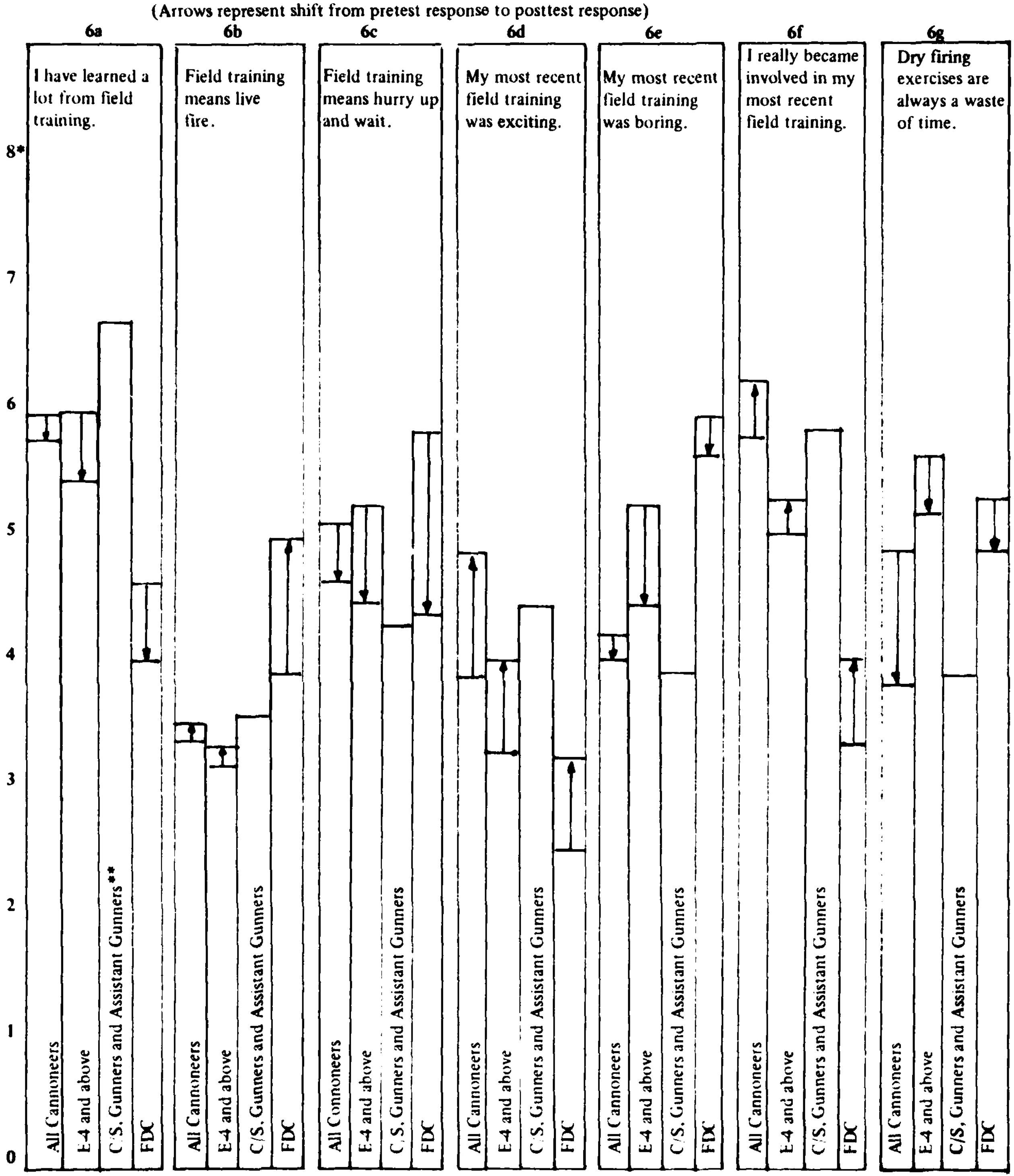
Gun battery and FDC personnel were administered a questionnaire before and after the test. Figure 5 presented the summary data graphically. (See Tabs 1 and 2 of Appendix G for details.) Questions 1 through 6 were asked before the test and the entire questionnaire was administered afterwards.** Responses were screened for response sets by comparing the replies to Question 6e ("My most recent field training was boring") and 6f ("I really became involved in my most recent field training"). It was considered that other than a neutral answer to 6e required an opposing non-neutral answer to 6f. Shift from pre-test to post-test opinion is indicated in Figure 5 by the direction of the arrow in the bar graph. These data will be discussed in a latter section of this paper.

*Mission 11 not included because gross FDC error would have placed Block I off the chart.

**Respondents were informed of their rights under informed consent rules. None declined to complete the questionnaire.

**Figure 5. Graphical Presentation of Questionnaire Responses**

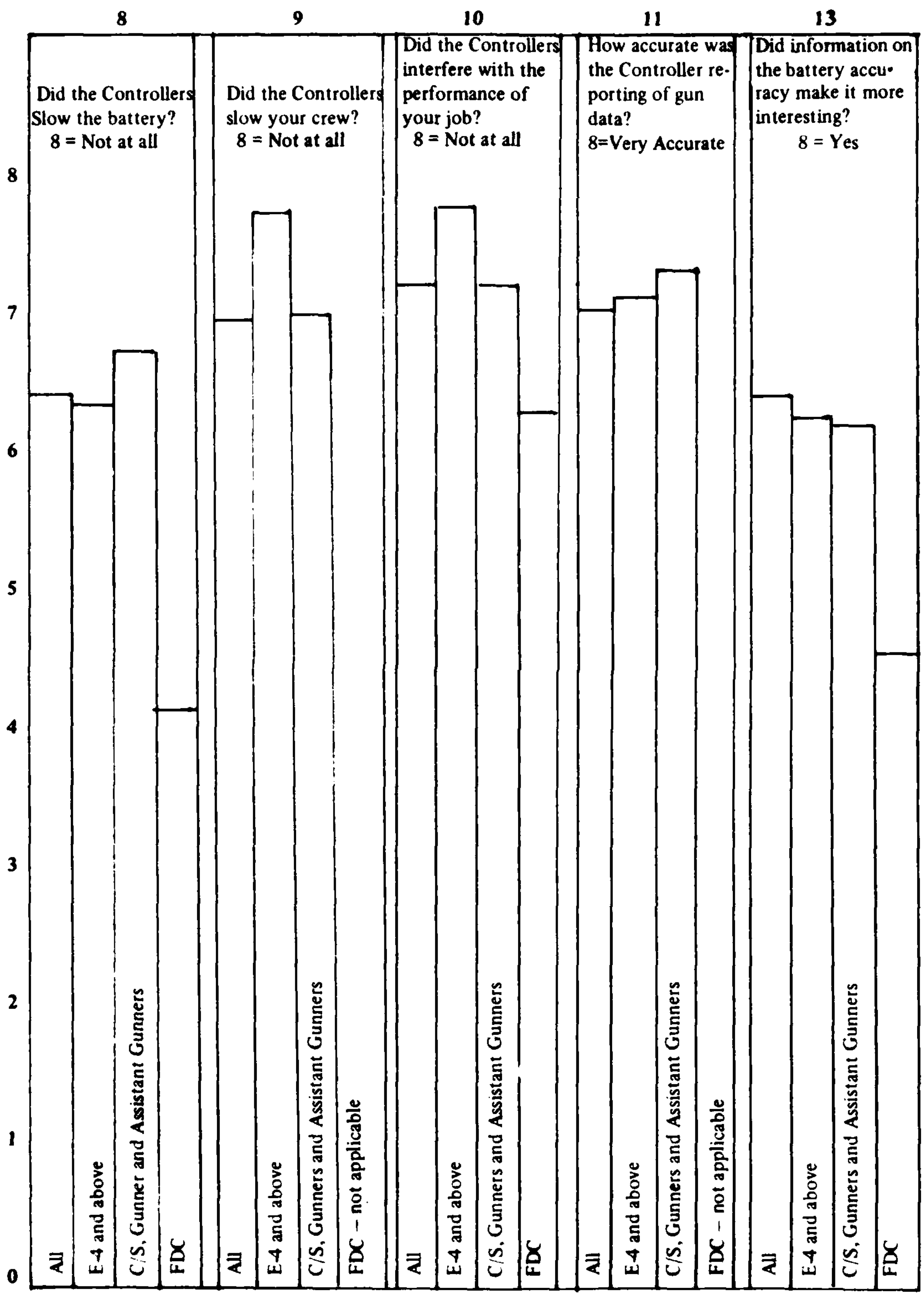
(Arrows represent shift from pretest response to posttest response)




*"8" indicates strong agreement with the statement.

**Post-test responses only. Identification as Chiefs of Section, Gunners and Assistant Gunners was not asked on the pre-test.

Figure 5 (Continued)



Cannoneers and FDC personnel also volunteered a number of written comments on the post-test questionnaires. Table 9 below summarizes the attitude toward the value of the training displayed in these comments. (See Tab 2 to Appendix G for transcription.) The degree to which comments reflected favorably or otherwise was made by the subjective judgment of the senior author.

**Table 9. Attitudes Toward Training Value of Cannoneer and FDC Personnel**

| | E-4 and Above | C/S and Gunners | All Cannoneers | FDC |
|---|---|---|---|---|
| Total number having comments | 11 | 4 | 9 | 4 |
| Favorable | 7 | 3 | 5 | 1 |
| Favorable with qualification | | | | 2 |
| Neutral or irrelevant | 4 | 1 | 4 | |
| Unfavorable | 1 | 1 | 1 | 1 |

FIST personnel were interviewed separately following the exercise using the interview guide at Tab 1 to Appendix H. The FIST personnel consisted of two O-1s, an E-6 and an E-5.

- All considered the speed and accuracy of ARES comparable to what they had seen in live fire.
- The ARES was perceived as being effective in simulating artillery effectiveness to maneuver unit commanders.
- All felt that the method provided them with better training than other non-firing methods. Two specifically preferred it to the 14.5 mm sub-caliber range, considering it more realistic as to speed and scale, and more motivating.
- Suggestions for improving the method called for more fire markers with more training and better prepositioning for the fire markers to lessen response time.

During the exercise it was observed that the FIST personnel became involved in the progress of a mission much as they would if adjusting live fire. Afterwards, the comment was volunteered that this was much better than the procedures now used in REALTRAIN. They stated that they felt the latter to be unrealistic in not conveying the actual response of an FDC and the possible errors of a firing battery. The random inaccuracy of the fire markers looked very much like the dispersion that they would have seen with live fire.

Fire markers were interviewed separately after the exercise using the interview guide at Tab 2 to Appendix H. There were two fire marking teams, each consisting of an E-5 and an E-3. All were FIST members, with from 10 months to 2 years' experience, and all considered themselves to be from adequately to very well qualified.

Responses to interview questions were as follows:

- Three considered the fire marker training to be adequate; one considered it more than needed as they did not use maps, just compasses and distance. One did, however, suggest more driver training on the terrain and another suggested more training in teamwork, specifically one man on the compass directing the other in pacing off the distance.

- All suggested that lensatic compasses be used instead of the M2 compass.

- All found the duties easy to perform, except for the physical exertion of crossing rough terrain.

- Two considered the experience to have had a lot of training value to them in their MOS and two considered it to have some value. In all cases, they said its contribution was to their land navigation skills.

- Two considered it to have improved their land navigation skills. The other team considered it to have made no difference "because we didn't use our maps."

- One volunteered the comment, based on his observation of the test and his own experience as a FIST member, that the method appeared useful for training FIST members in adjusting fire.

Fire Marker Control Center personnel were interviewed separately following the test using the interview guide at Tab 3 to Appendix H. The personnel consisted of an E-6 and an E-2 who considered themselves very well qualified and an E-3 who considered himself primarily a chart operator (the E-2 was in fact the better qualified).

Responses to interview questions were as follows:

- All considered the training they received to have been adequate.

- All considered the duties either easier or about the same as their normal duties.

- The two lower ranking EM considered the duties to have had a lot of training value in their MOS; the E-6 considered them to have had some training value.

- The following changes, or need for changes to the FMCC procedures, were suggested:

  - Changes were suggested to the Fire Marker Control Computer Record form.

  - The need was pointed out for procedures to handle Improved Conventional Munition (ICM) and irregularly shaped targets.

The gun controllers were interviewed separately following the exercise using the interview guide at Appendix 4 to Annex H. The two gun controllers who were interviewed were an E-5 and an E-3 with 3 years' and 1 year experience respectively on the howitzer. (The third gun controller, an E-4, was not available for interview at the end of the test.) Both considered themselves proficient cannoneers.

Responses to interview questions were as follows:

- The E-5 considered the training he received to be a controller to be more than needed; the E-3 considered it adequate. Neither suggested any changes.

- The duties were considered easy: "Anyone could do it." The E-5 suggested that an optimum ratio would be one controller per two howitzers.

- The E-5 considered that the experience had some training value to him in his MOS, by reinforcing his skills. The E-3 felt that it had no training value as it was entirely within the scope of skills he had already mastered.

- Neither felt that their activities interfered significantly with the gun crews.

The response of the control system personnel who were interviewed to the question of how much training value their experience in the exercise had to their MOS is summarized in Table 10 below.

None of the respondents felt that participation had been counterproductive to their MOS skill retention and four of the nine men considered it to have considerably enhanced their skills.

**Table 10. Control System Personnel's Estimate of ARES Training Value to Them**

| | Training Value | | |
|---|---|---|---|
| | A lot | Some | None |
| Gun Controllers | | 1 | 1 |
| FMCC | 2 | 1 | |
| Fire Markers | 2 | 2 | |

Initially, the firing battery personnel seemed indifferent toward the need for precision in what they considered to be another "dry firing" exercise. Gun controllers observed a number of errors of a few mils in gun settings and NCO supervision was lax. Midway through the first day, however, the firing battery personnel realized that settings on the guns really were being marked as they would have hit, given live ammunition. There was a noticeable increase in NCO supervision of firing battery procedures and the minor errors ceased. By the end of the day, the system appeared to have acquired full credibility with the battery.

Senior officers' judgment of the exercises and method was expressed at a meeting following the exercises. This was attended by the Battalion Commander, Battalion XO, S-3, Fire Support Officer, Fire Direction Officer, Battery Commander, Battery XO, and the research staff. The Battalion Commander had not visited the exercises, having just returned from TDY, but his staff had made daily visits. Their reports to him on what they had seen were quite thorough. The consensus of their reports, endorsed by the Battery Commander, was that the exercises had been a valuable training experience for all personnel involved. It was observed that, aside from its use in support of an ES exercise, the methodology had value as "stand alone" training method for field artillery units. Researcher observations are at Appendix I.

## Discussion

The data collected during this developmental test provide information on the timeliness and accuracy with which the control system can simulate the fires of a field artillery battery in an engagement simulation exercise. They also provide some information on the effect on the battery's performance and on the attitudinal change of the personnel involved. These data will be discussed in terms of the extent to which the methodology employed is feasible within the resources available to the battalion, has training value, and adequately simulates the fires of the battery.

The battery and battalion were able to provide a sufficient number of adequately qualified personnel from within existing resources to support the exercise. There were no indications in the comments of battalion or battery officers and NCO's that supporting these personnel requirements caused any serious unit problems.

The battalion was also able to provide all of the required equipment, except lensatic compasses, with no apparent difficulty. The fire markers were able to perform the task with the available M-2 compasses. There are some indications in the performance of the fire marker who did use a borrowed lensatic compass that the lensatic compass may be a more suitable instrument. Lensatic compasses should be available from the maneuver unit in an ES exercise situation.

The success of the training program to qualify the control system personnel in their tasks can be judged by the perception of the personnel themselves, the perceptions of those whose actions they checked, researcher observation, and the objective indicators of how well they actually performed the tasks.

All control system personnel considered themselves either adequately or more than adequately trained in the course of ½ day's instruction, and another ½ day's drill, though two fire markers did identify other training needs after the exercise began. The artillerymen whose actions were checked by the ARES controllers were also generally favorable in their comments on controller performance. The gun controllers, in fact, enjoyed a very high degree of confidence and acceptance in the firing battery. The one exception was the opinion of three of the four FIST personnel that they would have preferred better fire marker performance. Further discussion will show, however, that this was probably not a factor of training.

The responsiveness of the control system did demonstrate improvement when the central tendencies of four mission blocks were examined. The test controller training was sufficient to allow the battery to start its engagement simulation training exercises. The decrease in time required by the control system was the result of increased facility gained through experience.

The most recalcitrant element of the control system was the firemarking. The departure from the pattern of the rest of the control system shown by the firemarkers in third block of Table 3 may be representative of the effect of the unique situational variables of each mission, particularly the difference in the severity of the obstacles presented by gullies and swamps, rather than by any denigration of performance. That the poor performance in Block III was caused by such confounding factors is also suggested by the return to the general pattern in Block IV.

In considering the adequacy of the control system to simulate the fires of the battery, it is again noted that the principal source of error and delay is the fire marker. The gun controllers made no errors and had only one operational mishap (the unrealized loss of communications) in the course of 82 shots. The FMCC transmitted only one erroneous instruction. The gun controller and FMCC tasks were accomplished in a total average time of approximately two minutes. There were no adverse comments or observations on the performance of these elements of the control system. These considerations support an inference that these tasks were adequately performed. Although the fire markers took the greatest amount of time and introduced almost all of the error in the system, they were still perceived by the FIST members and the battalion staff officers as providing a good enough simulation for effective training. This perception is supported by the trend in objective indicators in battery performance (Tables 7 and 8) and specific observations by the experienced FIST members concerning improved realism over other training methods. It must also be remembered that this type of fire marking and this level of accuracy and responsiveness is not unique to this control system, but must be expected in any indirect fire simulation during engagement simulation exercises.

There is evidence that the use of the control system to simulate the battery's fires had substantial training value for all artillerymen involved and would have had training value

for supported maneuver unit soldiers. The trend to improved accuracy shown in Table 8 and Figure 4 is statistically significant. Comparing the data in successive blocks of Table 7 indicates a steady reduction in both the response time and the variability of the response time of the Artillery System.

Changes in attitude between pre- and post-test, shown in Figure 5, indicate generally favorable perceptions of the training by the troops. A larger number in all categories found the training exciting and really became involved in it. A smaller number found it boring or believed dry firing to be a waste of time. These shifts in perception indicate that, if increased interest is an indicator of improved learning, an improved learning environment did exist. The same can be said of the response to the last question, in which all soldiers except FDC members reported that the tactical feedback information on battery performance made the exercise more interesting to them. Only in Question 6a is an unfavorable shift evident, toward a lesser degree of agreement that "I have learned a lot from field training." There are several possible explanations for this seemingly aberrant shift in responses. One may be a perception by the troops that what they had done in the field was practice of what they had learned in garrison. Another possiblity may be that, they simply expected too much from the program and were therefore dissappointed.

A comparison between the post-test responses of the E-4's and above and the responses of those who served as chiefs of section, gunner and assistant gunner, shows those in the latter group were more positively affected by the training. The nine E-4s and above are included in the 17 chiefs of section, gunner and assistant gunners. The difference, therefore, is consistently made by the lower ranking EM, E-3 and below, who were given a chance to act as gunners and assistant gunners. It suggests that this method affords a chance to let the lesser skilled personnel practice gunning to a greater extent than might be risked with live fire, yet with the same level of check on their accuracy and speed.

The generally less enthusiastic responses of the FDC members reflect a condition that was observed by the research staff. Many of their skills can be learned as well in garrison as in the field. The value of field training requires an understanding of what the FDC contributes to and gets from teamwork in a battery exercise. The two junior EM in the FDC did not have this understanding and displayed a generally negative attitude, both in conversation and on their questionnaires. With only five respondents, this substantially biased the collective response.

The attitudinal shifts described in the structured part of the questionnaire were supported by the written comments shown in Table 9. The thrust of the favorable comments was toward the training opportunities of the method; the negative comments generally indicated an overall negativism rather than specific criticism of the method being tested.

Previous discussion has addressed the value of the ARES in training, in the delivery of artillery fire, i.e., the technical tasks. The interview responses of the FIST members and the opinions of the senior officers of the battalion staff provide evidence that it also has value in training in the effective employment of artillery fire. They considered the ARES speed and accuracy comparable to live fire, despite the imperfections in the present fire marking system. They also felt that the integration of field artillery into ES exercises would improve the training of both maneuver unit and artillery personnel in the teamwork required for effective indirect fire utilization. The psychological fidelity is reflected in the fact that the FIST members developed an involvement in a mission similar to that observed with live fire, probably at least partly due to the presence of the same element of chance and dispersion as exists in live fire. The interviews also indicated a perceived advantage of ARES for both tactical and technical tasks was that FIST members could work in a simulated tactical environment with realistic time delays and errors that could not be accepted in live fire exercises.

ARES personnel felt that serving as controllers had training value for them. The two computers in the FMCC considered the intensive drill in replot to have been very beneficial. Two of the fire markers similarly judged the exercise of land navigation skills to have had training value. Those who held the training to be of somewhat less value felt that it merely reinforced skills they already possessed. In no case was the experience judged counterproductive to their MOS qualifcations. This suggests that committing personnel to the control system for a limited period of time should be regarded as a training opportunity rather than a training loss.

ARES, as with any ES control system, must also be able to provide feedback to the maneuver and artillery unit leaders which can be used to assess performance, identify training needs and provide a basis for improving performance. When the artillery battery is incorporated in an ES exercise, there will be three types of feedback: tactical information to the battery on the effects of their fire, technical information to the battery on its gunnery, and tactical information to the FIST and maneuver commanders as to their use of artillery fire.

Though primarily developed to integrate artillery into ES exercises and thus to improve combined arms training, ARES was demonstrated to have additional training potential. FIST members were placed in a more realistic situation than they would have been in a live fire exercise. The CAC presentation of scenario events set up a credible tactical situation for the FIST members. They were closer to the action, the terrain was more varied and the delays, problems and planning considerations were those of the tactical situation and the capabilities and limitation of the firing battery, rather than range safety limitations.

There was a general feeling that the procedures provides all of the effects of live fire practice except ammunition handling and destructive effects of artillery projectiles with no expenditure of ammunition. This training can be accomplished on any terrain, except an impact area. This enlarges the area in which near-live fire artillery training can be conducted, increasing the variety of terrain that FIST members can practice on and the opportunities for batteries to get to the field for meaningful training.

# CHAPTER IV
# CONCLUSIONS AND RECOMMENDATIONS

## Conclusions

ARES can be implemented to simulate the fires of a battery within the resources of a direct support artillery battalion. This can be done in support of maneuver elements or as an artillery only exercise.

ARES does not degrade the accuracy or responsiveness of the artillery simulation.

ARES has training value for artillerymen in the firing battery, FDC, FIST and in the control system.

ARES, used in support of engagement simulation exercises, will enhance the tactical fidelity of the simulation of artillery and will have training value to maneuver unit commanders in terms of the capabilities and limitations of indirect fire, proper utilization of artillery, and the teamwork and planning factors required.

## Recommendations

The method employed in this developmental exercise should be further validated as to feasibility and training value with maneuver troops.

Procedures should be developed for more comprehensive incorporation of a fuller range of indirect fire systems and capabilities into ES exercises. The specific development efforts recommended are stated in Appendix J.

## APPENDIX A
## ARTILLERY VERIFICATION PROGRAM FOR HAND-HELD PROGRAMMABLE CALCULATOR, MODEL TI-59

### Purpose

The purpose of this portion of the research effort was to develop a program which the fire marker control computer, equipped with a Model TI-59 hand-held programmable calculator, could use to determine the grid coordinates of the burst point corresponding to a particular set of firing data and provide land navigation information to the fire marker. It can be used with either the M102 Howitzer or the M109A1 Howitzer. This section describes the program which was developed.

### Procedure

Instructions for use of the Artillery Verification Program are at Tabs 1 and 2. Tab 1 is a complete set of instructions for use by a well-qualified T1-59 calculator operator. Tab 2 is a "job aid" which will enable a person with no prior T1-50 experience to operate a properly initialized calculator. In summary, the sequence of events is:

- Use a magnetic card to load the ballistic constants into the calculator. (Since this program uses different addresses than the cannon artillery program, this must be done regardless of whether or not an artillery module is installed. It also means that the program can be run on any TI-59 calculator, whether or not it has an artillery module, provided it is partitioned into 479 program steps and 60 memory registers.)

- Use another magnetic card to load the Artillery Verification Program into the calculator.

- Enter the battery position, registration and fire marker reference point information.

- Run the program as each element of piece and ammunition data is announced, also entering the assumed or estimated target altitude.

- Read the grid coordinates of the burst point to the nearest 10 meters (eight place coordinates).

- Enter the position of the fire marker (not necessary if he is at a reference point or the previous burst point).

- Read the azimuth and distance from his position to the burst point.

## Rationale

Range is determined initially by solving the fitted quadratic equation:

$$\text{Range} = a_0 + a_1(el) + a_2(el)^2$$

where $a_0$, $a_1$ and $a_2$ are among the ballistic constants. This range is modified for met + VE or registration correction by multiplying it by a range K (did hit range ÷ chart range) and for vertical interval and HOB [1] by solving the equation

$$\Delta \text{ range} = \frac{VI + HOB}{\text{Tan}(el)}$$

Direction is determined by applying the difference between the deflection and 3,200 to the azimuth of lay of the battery. It is corrected for drift by determining how much the range differs from a center range for that charge and applying a drift correction which is the correction (center range and correction are among the ballistic constants) for that center range plus (minus) one mil for each 550 meters that the target range is greater (less) than the center range.[2] If a deflection correction has been determined, that total correction and the range at which it was determined are entered instead of the center range and drift correction.

Grid coordinates of the burst are determined using polar/rectangular conversion.

### Fire Marker Instructions

The location of the last burst calculated is stored. Up to four references as points can also be stored. If the fire marker is located at any of these points, his coordinates are already in the calculator. A rectangular/polar conversion is used to determine the azimuth and distance that he should move from that reference point or old burst point to the new burst point.

[1] Note that this program does not attempt to determine location of a time determined burst.

[2] 550 meters is selected as being the average range change for a 1 mil change in drift across charges 3 through 5GB and 6 and 7WB with the M109A1 Howitzer or charges 3 through 7 with the M102 Howitzer.

**Results**

The program was tested by selecting a target for each of the five charges in each of the four quadrants for both types of howitzers. Firing data were calculated for each of these targets using the TI-59 hand-held calculator with the artillery module. The grid coordinates corresponding to each of the sets of firing data were then calculated using the Artillery Verification Program and compared with the actual target coordinates. Results of that comparison are shown at Figure 1 for the M109A1 Howitzer and Figure 2 for the M102 Howitzer.

**Program Content**

The step-by-step Artillery Verification Program is shown at Tab 3. Tab 4 shows the ballistic constant program for the M109A1 Howitzer and Tab 5 for the M102 Howitzer. Assignment of memories and labels used in the program is shown at Tab 6.

**FIGURE 1: Comparison of TI and Manual Gunnery Solutions, and Artillery Verification Program Solution for M109A1**

| | Target Coordinates/ Altitude (Meters) | TI FDC Solution Charge/Deflection/QE | FMCC Generated Target Coordinates | Δ E (Meters) | Δ N (Meters) | Radial Error (Meters) |
|---|---|---|---|---|---|---|
| **First Quadrant** | | Firing Battery Coordinates | 93400 - 72600 | Laid on Azimuth 1000 | | Alt 73 Meters |
| | 9633 - 7498/93 | 3/3301/287 | 9632 - 7497 | 10 | 10 | 14 |
| | 9814 - 7604/99 | 4/3247/368 | 9813 - 7603 | 10 | 10 | 14 |
| | 9900 - 7700/82 | 5/3288/378 | 9899 - 7700 | 10 | 0 | 10 |
| | 0024 - 7706/93 | 6/3198/323 | 0023 - 7705 | 10 | 10 | 14 |
| | 0290 - 7678/93 | 7/3034/341 | 0288 - 7678 | 20 | 0 | 20 |
| **Second Quadrant** | | Firing Battery Coordinates | 91120 - 81200 | Laid on Azimuth 2000 | | Alt 94 Meters |
| | 9436 - 8000/130 | 3/3245/264 | 9435 - 8001 | 10 | 10 | 14 |
| | 9600 - 7900/104 | 4/3175/324 | 9600 - 7900 | 0 | 0 | 0 |
| | 9722 - 7835/79 | 5/3163/346 | 9723 - 7835 | 10 | 0 | 10 |
| | 9820 - 7963/94 | 6/3386/269 | 9820 - 7963 | 0 | 0 | 0 |
| | 9853 - 7633/76 | 7/3017/259 | 9856 - 7632 | 30 | 10 | 32 |
| **Third Quadrant** | | Firing Battery Coordinates | 02900 - 76780 | Laid on Azimuth 4200 | | Alt 93 Meters |
| | 9988 - 7505/89 | 3/3136/254 | 9988 - 7505 | 0 | 0 | 0 |
| | 9900 - 7400/94 | 4/3237/279 | 9901 - 7400 | 10 | 0 | 10 |
| | 9864 - 7305/84 | 5/3339/275 | 9864 - 7305 | 0 | 0 | 0 |
| | 9700 - 7200/90 | 6/3302/287 | 9700 - 7200 | 30 | | 0 |
| | 9340 - 7260/69 | 7/3034/336 | 9338 - 7258 | 20 | 20 | 28 |
| **Fourth Quadrant** | | Firing Battery Coordinates | 03710 - 71800 | Laid on Azimuth 5500 | | Alt 130 Meters |
| | 0020 - 7456/98 | 3/3230/341 | 0018 - 7457 | 20 | 10 | 22 |
| | 9944 - 7432/100 | 4/3363/285 | 9942 - 7432 | 20 | 0 | 20 |
| | 9873 - 7525/94 | 5/3290/296 | 9871 - 7526 | 20 | 10 | 22 |
| | 9700 - 7617/98 | 6/3322/307 | 9697 - 7618 | 30 | 10 | 32 |
| | 9564 - 7876/112 | 7/3188/353 | 9561 - 7876 | 30 | 0 | 30 |

**FIGURE 2: Comparison of TI Gunnery Solution and Artillery Verification Program Solution for M102**

| | Tgt Coord/Alt Meters | TI Gunnery Solution Chg/Defl/Quad | FMCC Generated Tgt Coord | △E Meters | △N Meters | Radial Error Meters |
|---|---|---|---|---|---|---|
| | Battery Location 28000 - 24000 | Az 1000 | Alt 100 Meters | | | |
| 1st Quadrant | 3053 - 2555/95 | 3/3165/277 | 3053 - 2556 | 0 | 10 | 10 |
| | 3070 - 2737/105 | 4/3518/343 | 3070 - 2737 | 0 | 0 | 0 |
| | 3246 - 2646/90 | 5/3119/303 | 3247 - 2647 | 0 | 10 | 10 |
| | 3232 - 2729/110 | 6/3268/266 | 3231 - 2729 | 10 | 0 | 10 |
| | 3425 - 2924/125 | 7/3318/350 | 3423 - 2923 | 20 | 10 | 22 |
| | Battery Location 28000 - 33000 | Az 2000 | Alt 200 Meters | | | |
| 2nd Quadrant | 3041 - 3203/203 | 3/3414/239 | 3041 - 3203 | 0 | 0 | 0 |
| | 3078 - 3076/197 | 4/3114/267 | 3078 - 3076 | 0 | 0 | 0 |
| | 3324 - 3032/210 | 5/3326/373 | 3324 - 3033 | 0 | 10 | 10 |
| | 3323 - 2912/190 | 6/3156/337 | 3324 - 2912 | 10 | 0 | 10 |
| | 3505 - 2786/201 | 7/3167/387 | 3505 - 2787 | 0 | 10 | 10 |
| | Battery Location 39000 - 33000 | Az 4400 | Alt 300 Meters | | | |
| 3rd Quadrant | 3576 - 3170/310 | 3/3195/345 | 3576 - 3170 | 0 | 0 | 0 |
| | 3522 - 3117/299 | 4/3265/329 | 3522 - 3117 | 0 | 0 | 0 |
| | 3314 - 3214/335 | 5/2955/380 | 3317 - 3214 | 30 | 0 | 30 |
| | 3308 - 2978/265 | 6/3314/350 | 3306 - 2976 | 20 | 20 | 28 |
| | 3168 - 2966/340 | 7/3243/344 | 3172 - 2967 | 40 | 10 | 41 |
| | Battery Location 39000 - 24000 | Az 5500 | Alt 400 Meters | | | |
| 4th Quadrant | 3690 - 2615/430 | 3/3094/293 | 3690 - 2614 | 0 | 10 | 10 |
| | 3553 - 2613/370 | 4/3346/309 | 3551 - 2613 | 20 | 0 | 20 |
| | 3527 - 2738/405 | 5/3155/301 | 3527 - 2737 | 0 | 10 | 10 |
| | 3392 - 2742/395 | 6/3302/310 | 3391 - 2742 | 10 | 0 | 10 |
| | 3127 - 3043/399 | 7/3206/501 | 3125 - 3041 | 20 | 20 | 41 |

## TAB 1
## INSTRUCTIONS FOR USE OF
## FIRE MARKING PROGRAM

### A. Prior to Receipt of Firing Data

1. Press CLR and 2nd CP.

2. Press "1."

3. Insert card marked "Ballistic Constants" for the appropriate type of howitzer in slot on right side of calculator with end marked "1" first. This will be passed through the calculator and should be removed on the other side.

4. Press "2."

5. Insert card with end marked "2" first. Remove after it has passed through calculator.

6. Press R/S. Calculator will run for approximately 6 seconds and display number 17.78 when completed.

7. Press "1."

8. Insert card marked "Firebat," end marked "1" first.

9. Press "2."

10. Insert other end of card, marked "2." Remove and store cards.

11. Press "RST."

12. Enter Battery Easting,* press "STO 00."

13. Enter Battery Northing,* press "STO 01."

14. Enter Battery Azimuth, press "STO 02."

15. Enter Battery Altitude (in meters), press "STO 03."

16. Enter Registration Correction:

| | | |
|---|---|---|
| Chg 3 | Rng K | STO 34 |
| | DF Corr | STO 33 |
| | Reg Rng | STO 32 |
| Chg 4 | Rng K | STO 40 |
| | DF Corr | STO 39 |
| | Reg Rng | STO 38 |

| | | | |
|---|---|---|---|
| GB for M109A1 | Chg 5 | Rng K | STO 46 |
| | | DF Corr | STO 45 |
| | | Reg Rng | STO 44 |
| | Chg 6 | Rng K | STO 52 |
| | | DF Corr | STO 51 |
| | | Reg Rng | STO 50 |
| | Chg 7 | Rng K | STO 58 |
| | | DF Corr | STO 57 |
| | | Reg Rng | STO 56 |

Rng K = did hit range ÷ chart range
DF Corr to right is negative

17. Enter altitude of target area (in meters), press "STO 12."***

18. Enter fire marker reference point coordinates* as follows:

| Ref Pt | Easting | Northing |
|---|---|---|
| A | STO 21 | STO 22 |
| B | STO 23 | STO 24 |
| C | STO 25 | STO 26 |
| D | STO 27 | STO 28 |

19. Press CLR.

20. Press R/S "0" will blink off, then on. Calculator is now ready to receive firing data.

## B. On Receipt of Firing Data**

1. Press code for selected charge:

"3" for charge 3GB (M109A1) or charge 3 (M102)
"4" for charge 4GB (M109A1) or charge 4 (M102)
"5" for charge 5GB (M109A1) or charge 5 (M102)
"6" for charge 6WB (M109A1) or charge 6 (M102)
"7" for charge 7WB (M109A1) or charge 7 (M102)

Then press R/S. Calculator will run for approximately 3 seconds and display "1."

2. Enter "20" (or other HOB if appropriate) if air burst fuze is selected, or "0" if surface burst fuze is selected. Press R/S. Calculator will blink off then display "3200."

3. Enter deflection and press R/S. Calculator will run for approximately one second then display direction of fire.

4. Enter quadrant elevation and press R/S. Calculator will run for approximately two seconds and display the altitude of the target area.

5. If another target altitude is desired, enter that number (in meters).***

6. Press R/S. Calculator will run for approximately 6 seconds and display the easting coordinate* of the burst point to 10 meter accuracy (4 digit number).

7. Press R/S. Calculator will run for approximately one second and display the northing coordinate* of the burst point to 10 meter accuracy (4 digit number).

8. If it is not desired to send azimuth and distance instructions to the fire marker, press "E CLR" and calculator is ready to receive next set of firing data.

## C. To Generate Azimuth and Distance Instructions to Fire Markers

1. *If the fire marker is at the location of the last burst point calculated*, press R/S after reading the northing coordinate. Skip over Steps 2 and 3, and read the data at Step 4.

2. *If the fire marker is at one of the reference points A, B, C or D*, press the corresponding letter on the calculator.

3. *If the fire marker is at a location other than the last burst point calculated or a reference point*, enter the easting coordinate* of his location and press "STO 19" then enter the northing coordinate* and press "STO 20." Press R/S.

4. On completion of Step 1, 2 or 3, calculator will run for approximately four seconds and display fire markers azimuth to new burst point in degrees.

5. Press R/S. Calculator will blink off and display distance the fire marker must travel to the new burst point in meters.

6. Press R/S. Calculator will blink off, display "0" and is now ready for the next set of firing data.

---

*Each component of the coordinate (easting and northing) must be entered with five numbers. If the location is not known that accurately, zeroes should be used. Thus, a location reported as 893-520 should be entered as 89300-52000. An exception is that if a coordinate component begins with "0" it must have a "1" put in front of it and if the burst location easting or northing begins with "0" it will be displayed with a "1" in front of it. For example, a battery location of 08925-52030 must be entered "108925-52030" and a burst location of "9334-0228" would be displayed as "9334-10228."

**In the event of an error, press "E CLR" and calculator is ready to begin again on the firing data.

***Do not use a target altitude the same as the battery altitude. If this is the case, enter an altitude one meter greater or less.

## TAB 2

1. If charge 3 is prepared, enter "3."
   If charge 4 is prepared, enter "4."
   If charge 5 is prepared, enter "5." (GB for M109A1)
   If charge 6 is prepared, enter "6."
   If charge 7 is prepared, enter "7." Then press R/S.

2. Enter "0" if fuzed for surface action, "20" (or other HOB) if fuzed for air action. Press R/S.

3. Enter deflection. Press R/S.

4. Enter quadrant elevation. Press R/S.

5. Read altitude of target area (in meters). If another target altitude should be used, enter it. Press R/S.

6. Read and record easting coordinate of burst point. Press R/S.

7. Read and record northing coordinate of burst point. Press R/S.

8. If fire marker is:

   a. at last burst point, press R/S.
   b. at a reference point, press letter for that point.

9. Read and transmit azimuth in degrees that fire marker should take from last burst to this one. Press R/S.

10. Read and transmit distance in meters that fire marker should travel on that azimuth. Press R/S.

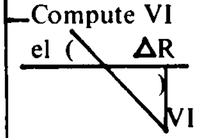
11. Calculator is ready for Step "1" of next set of firing data.

    In case of error, press "E CLR" and start over at Step 1.

## TAB 3

## ARTILLERY VERIFICATION PROGRAM

| Step Number | Function | Comment |
|---|---|---|
| 000 - 001 | FIX 0 | |
| 002 - 003 | LBL E | |
| 004 | R/S | |
| Enter Charge Code | | |
| 005 | $x \geq t$ | |
| 006 - 007 | 7 = | |
| 008 | x = t | |
| 009 | A´ | |
| 010 - 011 | 6 = | |
| 012 | x = t | Identify selected charge |
| 013 | B´ | |
| 014 - 015 | 5 = | |
| 016 | x = t | |
| 017 | C´ | |
| 018 - 019 | 4 = | |
| 020 | x = t | |
| 021 | D´ | |
| 022 - 025 | RCL 29 STO 16 | |
| 026 - 029 | RCL 30 STO 17 | |
| 030 - 033 | RCL 31 STO 18 | Load Chg Code 3 Constants |
| 034 - 037 | RCL 32 STO 06 | |
| 038 - 041 | RCL 33 STO 05 | |
| 042 - 045 | RCL 34 STO 04 | |
| 046 - 047 | GTO E´ | |
| 048 - 049 | LBL A´ | |
| 050 - 053 | RCL 53 STO 16 | |
| 054 - 057 | RCL 54 STO 17 | |
| 058 - 061 | RCL 55 STO 18 | Load Charge Code 7 Constants |
| 062 - 065 | RCL 56 STO 06 | |
| 066 - 069 | RCL 57 STO 05 | |
| 070 - 073 | RCL 58 STO 04 | |
| 074 - 075 | GTO E´ | |
| 076 - 077 | LBL B´ | |
| 078 - 081 | RCL 47 STO 16 | |
| 082 - 085 | RCL 48 STO 17 | |
| 086 - 089 | RCL 49 STO 18 | Load chg Code 6 constants |
| 090 - 093 | RCL 50 STO 06 | |
| 094 - 097 | RCL 51 STO 05 | |
| 098 - 101 | RCL 52 STO 04 | |
| 102 - 103 | GTO E´ | |
| 104 - 105 | LBL C´ | |

| Step Number | Function | Comment |
|---|---|---|
| 106-109 | RCL 41 STO 16 | |
| 110-113 | RCL 42 STO 17 | |
| 114-117 | RCL 43 STO 18 | Load chg Code 5 constants |
| 118-121 | RCL 44 STO 06 | |
| 122-125 | RCL 45 STO 05 | |
| 126-129 | RCL 46 STO 04 | |
| 130-131 | GTO E′ | |
| 132-133 | LBL D′ | |
| 134-137 | RCL 35 STO 16 | |
| 138-141 | RCL 36 STO 17 | |
| 142-145 | RCL 37 STO 18 | Load chg Code 4 constants |
| 146-149 | RCL 38 STO 06 | |
| 150-153 | RCL 39 STO 05 | |
| 154-157 | RCL 40 STO 04 | |
| 158-159 | LBL E″ | |
| 160 | R/S | Display 1 |
| | Enter HOB or 0 for surface burst | |
| 161-162 | STO 13 | |
| 163-167 | 3200– | |
| 168 | R/S | Display 3200 |
| | Enter deflection | |
| 169 | = | |
| 170-173 | + RCL 02 = | |
| 174-175 | STO 09 | |
| 176 | R/S | Display direction of fire |
| | Enter elevation | |
| 177-178 | STO 14 | |
| 179-181 | RCL 18+ | Calculate range |
| 182-187 | RCL 17 x RCL 14 = | $r = a_0 + a_1 (el) + a_2(el)^2$ |
| 188-195 | + RCL 16 x RCL 14$x^2$ = | |
| 196-199 | ÷ RCL 04 = | |
| 200-201 | STO 15 | |
| 202-203 | RCL 12 | |
| 204 | R/S | Display target altitude |
| | Enter new target altitude if desired | |
| 205-208 | – RCL 03 = | |
| 209-212 | + RCL 13 = | Compute VI |
| 213 | +/- |   |
| 214-215 | STO 07 | |
| 216-221 | RCL 14 ÷ RCL 59 = | |
| 222 | TAN | $\Delta R = \frac{VI}{Tan (el)}$ |
| 223-226 | ÷ RCL 07 = | |
| 227 | 1/x | |
| 228-231 | + RCL 15 = | |
| 232-233 | STO 15 | |

| Step Number | Function | Comment |
|---|---|---|
| 234-237 | − RCL 06 = | |
| 238-242 | ÷ 550 = | |
| 243-246 | + RCL 05 = | Apply drift or deflection correction |
| 247-250 | + RCL 09 = | |
| 251-252 | STO 09 | |
| 253-256 | RCL 10 STO 19 | Save last coordinates |
| 257-260 | RCL 11 STO 20 | |
| 261-262 | RCL 15 | |
| 263 | $x \gtrless t$ | |
| 264-265 | RCL 09 | |
| 266-269 | ÷ RCL 59 = | Solve polar coordinates to rectangular |
| 270 | P → R | |
| 271-274 | + RCL 00 = | |
| 275-276 | STO 10 | |
| 277-280 | ÷ 10 = | |
| 281 | R/S | |
| Read target easting | | |
| 282 | $x \gtrless t$ | |
| 283-286 | + RCL 01 = | |
| 287-288 | STO 11 | |
| 289-292 | ÷ 10 = | |
| 293 | R/S | |
| Read target northing | | |
| 294-295 | LBL EE | |
| 296-301 | RCL 10 - RCL 19 = | |
| 302-303 | STO 07 | |
| 304-309 | RCL 11 - RCL 20 = | |
| 310 | $x \gtrless t$ | |
| 311-312 | RCL 07 | |
| 313-314 | INV P → R | |
| 315-316 | STO 08 | |
| 317 | $x \gtrless t$ | |
| 318-319 | STO 09 | |
| 320 | CLR | |
| 321 | $x \gtrless t$ | |
| 322-323 | RCL 08 | |
| 324 | $x \geq t$ | |
| 325 | $y^x$ | |
| 326-330 | + 360 = | |
| 331-332 | LBL $y^x$ | |
| 333 | R/S | |
| Read fire marker's azimuth from last burst | | |
| 334-335 | RCL 09 | |
| 336 | R/S | |
| Read fire marker's distance from last burst | | |
| 337 | CLR | |
| 338-339 | GTO E | |
| 340-341 | LBL A | |

| Step Number | Function | Comment |
|---|---|---|
| 342-345 | RCL 21 STO 19 | |
| 346-349 | RCL 22 STO 20 | |
| 350-351 | GTO EE | |
| 352-353 | LBL B | |
| 354-357 | RCL 23 STO 19 | |
| 358-361 | RCL 24 STO 20 | |
| 362-363 | GTO EE | |
| 364-367 | LBL C | |
| 368-371 | RCL 25 STO 19 | |
| 372-373 | RCL 26 STO 20 | |
| 374-375 | GTO EE | |
| 376-379 | LBL D | |
| 380-383 | RCL 27 STO 19 | |
| 384-385 | RCL 28 STO 20 | |
| 386-389 | GTO EE | |

## TAB 4
## M109A1 BALLISTIC CONSTANT PROGRAM

| Step Number | Function | Comment |
|---|---|---|
| 000-007 | .0104746 | |
| 008 | +/– | |
| 009-010 | STO 29 | |
| 011-017 | 16.9089 | |
| 018-019 | STO 30 | Chg Code 3 Chg 3GB |
| 020-022 | 156 | |
| 023 | +/– | |
| 024-025 | STO 31 | |
| 026-029 | 4000 | |
| 030-031 | STO 32 | |
| 032 | 7 | |
| 033-034 | STO 33 | |
| 035 | 1 | |
| 036-037 | STO 34 | |
| 038-044 | .013367 | |
| 045 | +/– | |
| 046-047 | STO 35 | |
| 048-054 | 21.2691 | |
| 055-056 | STO 36 | |
| 057-061 | 105.7 | Chg Code 4 Chg 4 GB |
| 062 | +/– | |
| 063-064 | STO 37 | |
| 065-068 | 5100 | |
| 069-070 | STO 38 | |
| 071 | 6 | |
| 072-073 | STO 39 | |
| 074 | 1 | |
| 075-076 | STO 40 | |
| 077-084 | .0149331 | |
| 085 | +/– | |
| 086-087 | STO 41 | |
| 088-094 | 24.3439 | |
| 095-096 | STO 42 | |
| 097-100 | 64.7 | Chg Code 5 Chg 5 GB |
| 101-102 | STO 43 | |
| 103-106 | 6000 | |
| 107-108 | STO 44 | |
| 109 | 7 | |
| 110-111 | STO 45 | |
| 112 | 1 | |
| 113-114 | STO 46 | |

| Step Number | Function | Comment |
|---|---|---|
| 115-122 | .0162072 | |
| 123 | +/– | |
| 124-125 | STO 47 | |
| 126-131 | 27.4137 | |
| 132-133 | STO 48 | Chg Code 6 |
| 134-139 | 1049.6 | Chg 6 WB |
| 140-141 | STO 49 | |
| 142-145 | 7800 | |
| 146-147 | STO 50 | |
| 148 | 9 | |
| 149-150 | STO 51 | |
| 151 | 1 | |
| 152-153 | STO 52 | |
| 154-161 | .0173835 | |
| 162 | +/– | |
| 163-164 | STO 53 | |
| 165-171 | 29.8741 | |
| 172-173 | STO 54 | |
| 174-179 | 2255.2 | |
| 180-181 | STO 55 | Chg Code 7 |
| 182-185 | 9650 | Chg 7 WB |
| 186-187 | STO 56 | |
| 188-189 | 10 | |
| 190-191 | STO 57 | |
| 192 | 1 | |
| 193-194 | STO 58 | |
| 195-199 | 17.78 | Mils/degree |
| 200-201 | STO 59 | |
| 202 | R/S | |

## TAB 5

## M102 BALLISTIC CONSTANT PROGRAM

| Step Number | Function | Comment |
|---|---|---|
| 000 - 007 | .0084637 | |
| 008 | +/– | |
| 009 - 010 | STO 29 | |
| 011 - 017 | 13.5244 | |
| 018 - 019 | STO 30 | |
| 020 - 024 | 141.6 | |
| 025 | +/– | Chg Code 3 |
| 026 - 027 | STO 31 | Charge 3 |
| 028 - 031 | 2825 | |
| 032 - 033 | STO 32 | |
| 034 | 4 | |
| 035 - 036 | STO 33 | |
| 037 | 1 | |
| 038 - 039 | STO 34 | |
| 040 - 047 | .0104853 | |
| 048 | +/– | |
| 049 - 050 | STO 35 | |
| 051 - 057 | 16.5687 | |
| 058 - 059 | STO 36 | |
| 060 - 062 | 120 | |
| 063 | +/– | Chg Code 4 |
| 064 - 065 | STO 37 | Charge 4 |
| 066 - 069 | 4000 | |
| 070 - 071 | STO 38 | |
| 072 | 5 | |
| 073 - 074 | STO 39 | |
| 075 | 1 | |
| 076 - 077 | STO 40 | |
| 078 - 085 | .0130772 | |
| 086 | +/– | |
| 087 - 088 | STO 41 | |
| 089 - 095 | 20.7905 | |
| 096 - 097 | STO 42 | |
| 098 - 101 | 27.7 | |
| 102 | +/– | |
| 103 - 104 | STO 43 | Chg Code 5 |
| 105 - 108 | 5100 | Charge 5 |
| 109 - 110 | STO 44 | |
| 111 | 5 | |
| 112 - 113 | STO 45 | |
| 114 | 1 | |
| 115 - 116 | STO 46 | |

| Step Number | Function | Comment |
|---|---|---|
| 117 - 124 | .0141168 | |
| 125 | +/– | |
| 126 - 127 | STO 47 | |
| 128 - 134 | 23.0803 | |
| 135 - 136 | STO 48 | |
| 137 - 141 | 316.7 | Chg Code 6 |
| 142 - 143 | STO 49 | Charge 6 |
| 144 - 147 | 6000 | |
| 148 - 149 | STO 50 | |
| 150 | 5 | |
| 151 - 152 | STO 51 | |
| 153 | 1 | |
| 154 - 155 | STO 52 | |
| 156 - 163 | .0151395 | |
| 164 | +/– | |
| 165 - 166 | STO 53 | |
| 167 - 173 | 25.1675 | |
| 174 - 175 | STO 54 | |
| 176 - 179 | 1249 | Chg Code 7 |
| 180 - 181 | STO 55 | Charge 7 |
| 182 - 185 | 7600 | |
| 186 - 187 | STO 56 | |
| 188 | 6 | |
| 189 - 190 | STO 57 | |
| 191 | 1 | |
| 192 - 193 | STO 58 | |
| 194 - 198 | 17.78 | |
| 199 - 200 | STO 59 | |
| 201 | R/S | |

## TAB 6

## LABEL AND MEMORY ASSIGNMENTS

### Labels

| | |
|---|---|
| A | Load coordinates for fire marker reference point A |
| B | Load coordinates for fire marker reference point B |
| C | Load coordinates for fire marker reference point C |
| D | Load coordinates for fire marker reference point D |
| E | Reset to accept new firing data |
| A′ | Load charge 7 ballistic constants |
| B′ | Load charge 6 ballistic constants |
| C′ | Load charge 5 ballistic constants |
| D′ | Load charge 4 ballistic constants |
| E′ | Resume program after loading ballistic constants |
| EE | Resume program after loading coordinates of fire marker reference points |
| $y^x$ | Computation for azimuths greater than full circle |

### Memories

| | |
|---|---|
| 00 | Battery Easting |
| 01 | Battery Northing |
| 02 | Battery Azimuth |
| 03 | Battery Altitude |
| 04 | Range K for selected charge |
| 05 | Deflection correction for selected charge |
| 06 | Registration range for selected charge |
| 07 | VI, difference in easting of burst and fire marker positions |
| 08 | Fire markers azimuth to burst point |
| 09 | Direction of fire, fire marker distance to burst point |
| 10 | Target Easting |
| 11 | Target Northing |
| 12 | Assumed or estimated target altitudes |
| 13 | HOB |
| 14 | QE |
| 15 | Range |
| 16 | $A_2$ for selected charge |
| 17 | $A_1$ for selected charge |
| 18 | $A_0$ for selected charge |
| 19 | Easting of fire marker position or last burst point |
| 20 | Northing of fire marker position or last burst point |
| 21 | Easting of fire marker reference point A |
| 22 | Northing of fire marker reference point A |
| 23 | Easting of fire marker reference point B |
| 24 | Northing of fire marker reference point B |

**Memories (Continued)**

| | | |
|---|---|---|
| 25 | Easting of fire marker reference point C | |
| 26 | Northing of fire marker reference point C | |
| 27 | Easting of fire marker reference point D | |
| 28 | Northing of fire marker reference point D | |
| 29 | $A_2$ | |
| 30 | $A_1$ | |
| 31 | $A_0$ | Code Charge 3 |
| 32 | Center or registration range | |
| 33 | Drift or deflection correction | |
| 34 | Range K | |
| 35 | $A_2$ | |
| 36 | $A_1$ | |
| 37 | $A_0$ | Code charge 4 |
| 38 | Center or registration range | |
| 39 | Drift or deflection correction | |
| 40 | Range K | |
| 41 | $A_2$ | |
| 42 | $A_1$ | |
| 43 | $A_0$ | Code charge 5 |
| 44 | Center or registration range | |
| 45 | Drift or deflection correction | |
| 46 | Range K | |
| 47 | $A_2$ | |
| 48 | $A_1$ | |
| 49 | $A_0$ | Code charge 6 |
| 50 | Center or registration range | |
| 51 | Drift or deflection correction | |
| 52 | Range K | |
| 53 | $A_2$ | |
| 54 | $A_1$ | |
| 55 | $A_0$ | Code charge 7 |
| 56 | Center or registration range | |
| 57 | Drift or deflection correction | |
| 58 | Range K | |
| 59 | 17.78 | |

## APPENDIX B

## TEST DESIGN PLAN

### I. INTRODUCTION

#### A. Purpose and Scope

1. This test is designed to evaluate a method of simulating indirect fire in engagement simulation exercises to accurately reflect the work done by all members of the indirect fire delivery system, i.e., Fire Support Team (FIST), Fire Direction Center (FDC) and Firing Battery (FB).

2a. Test will be conducted in two phases;

- Phase I–Training of gun controllers, fire markers and Fire Marker Control Center (FMCC).
- Phase II–Field Exercise.

b. The field exercise will be a non-firing exercise of a field artillery battery operating as part of a notional battalion in direct support of a notional maneuver force. Quantitative data on time to process missions, accuracy, speed and completeness of feedback will be gathered. An evaluation will be made of interference with normal operations, ease of execution of control methods and the training value of feedback to members of the FB.

3. Players will consist of a direct support field artillery battery and a FIST. They will operate in a European-type, non-nuclear environment. The FIST will transmit fire requests and tactical information as directed by the research team. The FDC and FB will execute these missions, displace as indicated by tactical considerations and provide its own security. Gun controllers and FMCC will determine where live rounds would have landed and direct fire markers to detonate simulators at the impact coordinates. Flash base observers will measure the accuracy of the marking.

4. Test milestones:

| | |
|---|---|
| Test Design Plan Firm | T-60 |
| Initial Contact with Test Unit | T-45 |
| Test Coordination Meeting | T-45 |
| Remaining TBD Items Firm | T-30 |

| | |
|---|---|
| Training POI Firm | T-30 |
| Lesson Plans Firm | T-30 |
| Detailed Test Plan Firm | T-15 |
| Mark Training Lanes | T-Day |
| Start Training Control Personnel | T+ 1 |
| Start Exercise | T+ 3 |
| Conclude Test Operations | T+ 7 |
| Initial Review of Reduced Data | T+18 |
| Test Conclusions Firm | T+32 |
| Draft Final Report Complete | T+46 |

Recommended T-Day is 15 October 1979.

## B. Background

1. **History.** To date, indirect fire in engagement simulation has involved only the FIST and an FMCC. In the current system, FIST requested fire from an FMCC. The FMCC directed the fire marker to the impact point requested by the FIST. It is assumed that the FDC and FB make no errors. Furthermore, neither the maneuver unit nor the supporting artillery received training in fire support coordination, the proper use of artillery, displacement to support the maneuver plan and other techniques necessary for success on the battlefield. At the request of the Field Artillery School, the Army Research Institute has undertaken the development of a system which will incorporate the field artillery into engagement simulation exercises. Elements of the system were tested for feasibility at Fort Sill in June 1979. Evaluation of the system, using a line direct support battery, is now necessary.

2. **System Description.** The control and simulation system to be tested consists of an FMCC, gun controller(s) and fire markers. The FMCC monitors the fire request and orders a fire marker to move to the vicinity of the target coordinates. The gun controller checks the data (charge, fuze, deflection, quadrant elevation) set at the piece and transmits these data to the FMCC. The FMCC computes the impact coordinates that result from these data and orders the fire marker to detonate simulator(s) at that location. At the end of each mission, the fire marker reports the effects of the indirect fire to the FMCC, which then gives feedback to the FB. At the end of the exercise, an After Action Review is held to discuss the units performance. After return to garrison, logs of all activities will be analyzed to determine any errors that may have been committed by the FIST, FDC, and/or FB. These will be fed back to the battery commander for remedial training.

3. The Test objectives are to determine the following:

a. Does the system accurately depict the results of the activities of all elements of the indirect fire system, i.e., FIST, FDC and FB?

b. How much time delay is introduced by the various elements of the control system?

c. What are the differences in time and accuracy between a manual and a calculator solution for the burst points of simulated mission?

d. Can the controllers be trained in two days?

## II. TEST CONDITIONS

### A. Factors and Conditions

1. Personnel stability during the test must be maintained.

2. Support personnel must meet standards in the following areas prior to test:

- Gun Controllers: Qualified and experienced as gunner.
- Fire markers: Map reading ability.
- FMCC: Qualified and experienced as computer.

3. Support personnel will be employed as follows:

- Three gun controllers, MOS 13B, and three fire marker controllers, MOS 13F, will be tested. Analysis will be based on mean time and accuracy of all controllers.

- Two fire markers, MOS 13F, will be tested. Analysis will be on mean time and accuracy of both fire markers, with possible adjustment for distance traveled.

- After each simulated round, a researcher will check and record data set on the piece. Deliberate errors will be introduced during missions to check controllers.

- Amount of shift between rounds at the piece and on the ground will be recorded. Adjustments will be made in the data analysis as needed.

B. **Events Summary**

1. **Pre T-Day**—Research team does a map reconnaissance of the training area and determines approximate location of firing battery locations, FIST and flash base OP's checkpoints and targets. Research team prepares fire mission list and confirms lesson plans for the training phase.

**T-Day**—Research team, with the help of flash base team, executes ground reconnaissance of training area, firms up all locations, marks checkpoints as necessary. Final coordination meeting in garrison with Phase I personnel.

**T+1**—Research team members train following teams:

- FIST and fire markers—map/terrain association, sequence of commands in fire requests.
- Gun controllers and crew—control procedures.
- Fire marker control center—control procedures.

Team drill of all elements of the control system will start in the afternoon. Flash base will establish OP's and check fire marker accuracy.

**T+2**—Intensive team drill of all elements of the control system. Final coordination meeting with officers and key NCO's of the howitzer battery.

**T+3 to T+4**—Measurement of baseline data on time and accuracy of howitzer battery. Test of control system with the battery in direct support of a notional maneuver force in the attack.

**T+4 to T+7**—Test of control system with the battery in support of notional maneuver force in the defense.

2. Matrix of mission to be employed:

a. Matrix Code:

Gun controllers are numbered 1, 2 and 3

Fire marker controllers are lettered A, B and C

Q = Fuze Quick

VT = Fuze Variable Time

MT = Fuze Mechanical Time

Q/VT = Adjust with Fuze Quick, fire for effect with Fuze Variable Time

| | | |
|---|---|---|
| Tgt Opp | = | Target of Opportunity |
| HE | = | High Explosive Projectile |
| AF | = | Adjust Fire Mission (Maximum 5 rounds in adjustment) |
| FFE | = | Fire for Effect Mission (Battery 1 round) |

b. Sequence of Events Per Mission. Fire requests will be initiated by researcher to a FIST member. Time starts when FIST member identifies the target. Fire request will be sent over normal channels to FDC, which will process the mission. FMCC will monitor fire request net and position a fire marker near the requested target location as early as possible. FDC will send data to gun crew(s) using normal procedures. Gun controller will observe data set on ammunition and piece, and transmit same to FMCC. FMCC will compute impact coordinates and order fire marker to detonate simulator(s) at that location. Flash base will observe detonation and plot actual impact points. Time ends when simulator detonates.

| Controller | Method of Fire | | Method of Computation | | Fuze | | | | Total Missions |
|---|---|---|---|---|---|---|---|---|---|
| | AF | FFE | TI-59 | Manual | MT | Q | Q/VT | VT | |
| Baseline | 6 | 0 | – | – | 0 | 0 | 6 | 0 | 6 |
| 1 | 6 | 4 | | | 2 | 3 | 4 | 1 | 10 |
| 2 | 6 | 4 | | | 2 | 3 | 5 | 0 | 10 |
| 3 | 6 | 4 | | | 2 | 3 | 4 | 1 | 10 |
| A | 6 | 4 | 5 | 5 | 2 | 4 | 4 | 0 | 10 |
| B | 5 | 5 | 5 | 5 | 3 | 4 | 2 | 1 | 10 |
| C | 7 | 3 | 5 | 5 | 1 | 1 | 7 | 1 | 10 |
| Total Missions | 24 | 12 | 15 | 15 | 6 | 9 | 19 | 2 | 36 |

**Figure 1**
**Master Mission Matrix**

| Mission Number | Controller ID | Computation Method | Fuze | Type of Target | Type of Mission |
|---|---|---|---|---|---|
| 1 | Baseline | – | Q/VT | Tgt Opp | HE/AF |
| 2 | 1/A | TI-59 | MT | Screen | Smoke/AF |
| 3 | 2/B | Manual | Q/VT | Tgt Opp | HE/AF |
| 4 | 3/C | TI-59 | Q/VT | Tgt Opp | HE/AF |
| 5 | 1/B | TI-59 | VT | Prep | HE/FFE |
| 6 | 2/C | Manual | MT | Preplanned | Smoke/FFE |
| 7 | 3/A | Manual | Q | Suppression | HE/FFE |
| 8 | Baseline | – | Q/VT | Tgt Opp | HE/AF |
| 9 | 1/C | TI-59 | Q/VT | Tgt Opp | HE/AF |
| | | Battery | Displaces | | |
| 10 | 2/A | Manual | Q/VT | Tgt Opp | HE/AF |
| 11 | 3/B | Manual | MT | Tgt Opp | HE/AF |
| 12 | 2/C | Manual | Q/VT | Tgt Opp | HE/AF |
| 13 | 3/A | TI-59 | Q/VT | Tgt Opp | HE/AF |
| 14 | 1/B | TI-59 | Q/VT | Tgt Opp | HE/AF |
| 15 | 3/C | TI-59 | VT | Tgt Opp | HE/FFE |
| 16 | 1/A | TI-59 | Q | Tgt Opp | HE/FFE |
| 17 | 2/B | Manual | Q | Suppression | HE/FFE |
| 18 | Baseline | – | Q/VT | Tgt Opp | HE/AF |

**Figure 2**
**Sequence of Missions; Attack Phase T+ 3 to T+ 4**

| Mission Number | Controller ID | Computation Method | Fuze | Type of Target | Type of Mission |
|---|---|---|---|---|---|
| 1 | Baseline | – | Q/VT | Tgt Opp | HE/AF |
| 2 | 3/B | TI-59 | MT | Screen | Smoke/AF |
| 3 | 2/A | Manual | Q/VT | Tgt Opp | HE/AF |
| 4 | 1/C | Manual | Q/VT | Tgt Opp | HE/AF |
| 5 | 2/B | Manual | Q | Preplanned | HE/FFE |
| 6 | 3/C | TI-59 | Q/VT | Tgt Opp | HE/AF |
| 7 | 1/A | TI-59 | MT | Screen | Smoke/AF |
| 8 | Baseline | – | Q/VT | Tgt Opp | HE/AF |
| 9 | 3/A | Manual | Q/VT | Tgt Opp | HE/AF |
| | | Battery | Displaces | | |
| 10 | 2/C | TI-59 | Q/VT | Tgt Opp | HE/AF |
| 11 | 1/B | TI-59 | Q | Preplanned | HE/FFE |
| 12 | 2/A | TI-59 | Q | Preplanned | HE/FFE |
| 13 | 3/B | Manual | Q | Final Protective | HE/FFE |
| 14 | 1/C | Manual | Q/VT | Tgt Opp | HE/AF |
| 15 | 2/B | TI-59 | MT | Screen | Smoke/AF |
| 16 | 3/C | Manual | Q | Suppression | HE/FFE |
| 17 | 1/A | Manual | Q | Suppression | HE/FFE |
| 18 | Baseline | | Q/VT | Tgt Opp | HE/AF |

**Figure 3**
**Sequence of Missions: Defense Phase T+ 4 and T+ 7**

| | Baseline | Computation: Manual | Computation: Calculator |
|---|---|---|---|
| FIST, FDC, crew time–target identification to simulated firing | X | X | X |
| Gun controller time–simulated firing to transmission of last data item to FMCC | | X | X |
| Computation time–receipt of last data item to end of transmission of order to fire marker | | X | X |
| Fire marker time and distance–receipt of order to detonation of first simulator; distance traveled | | X | X |

**Figure 4**
**Times to be measured and compared**

b. Accuracy of computation: Missions will be recomputed. Errors in northing, easting and radial error will be computed.

c. Accuracy of fire markers: Ordered and actual impact coordinates will be compared.

2. Operational Test Criteria:

a. Accuracy:

- Gun controllers must read
  –charge exactly as cut
  –fuze setting to 0 sec accuracy for fuze VT and 0.1 second accuracy for fuze time
  –deflection and quadrant elevation to 0 mils accuracy
- FMCC must determine impact coordinates within 100 meters accuracy in northing and easting.
- Fire markers must detonate simulator within 100 meters of announced coordinates.

## III. DATA REQUIREMENTS

### A. Instrumentation

1. Stop watches will be used to measure total time per mission and per round, time used by fire marker, time used by gun controller, and time used by FMCC computer.

2. Standard flash base instruments will be used to determine impact coordinates of simulators.

3. Fire control equipment (aiming circle, panoramic telescope, collimator) will be used to measure direction and elevation of fire.

**B. Manual.** Charge and fuze will be determined by inspection of training ammunition.

C. Controller interference with battery operation will be assessed using a rating scale procedure.

## IV. DATA ANALYSIS LOGIC

### A. Comparisons to be Made

1. Mean time to complete:

   (a) baseline missions
   (b) missions with manual computation at FMCC
   (c) missions with calculator computation at FMCC

2. Accuracy of manual versus calculator computations

3. Accuracy of fire markers

### B. Techniques for Each Comparison

1. Measures used:

   a. Time will be kept as follows:

b. Time:

- Gun controllers must announce data set on ammunition and piece no later than one minute after chief of section reports piece ready to fire.
- FMCC must transmit coordinates to fire marker no later than one minute after receipt of QE from gun controller.
- Fire should be marked no later than five minutes after chief of section reports piece ready to fire.

## V. APPROACH TO CONDUCT OF TEST

A. **Control Concept.** Prior to T-Day, and based on map reconnaissance, the research team will write a detailed scenario for the test. The scenario will include suggested locations of assembly areas, firing points, alternate firing points, observation posts, targets and times for each event. The scenario will be coordinated with the test unit to insure that all procedures are consistent with the test units tactical SOP. On T-Day, researchers will select exact locations for all of the above. During the test, one researcher will control the FIST. This researcher acting as the maneuver company commanders, will initiate missions by identifying targets to observers and will time and terminate missions. One researcher will monitor the gun data collectors. A third researcher will monitor FMCC activities. The senior researcher will play the part of the field artillery battalion commander. As such, he will designate firing position areas and directions of fire to the FB commander.

B. **Data Collection Concept.** See paragraph IIIA above.

C. **Data Reduction Concept.** See paragraph IV above.

D. **Resources Required**

1. Personnel

| Position | Grade | Qual. | No. | Source |
|---|---|---|---|---|
| Test Directorate | | | | |
| OIC | 03/04 | FA | 1 | |
| NCOIC | E7/E8 | 13 B/E | 1 | |
| Research Scientist | Civilian | | 4 | ARI/HSR |
| Driver, ¼-ton | E3/E4 | | 3 | |
| Phase 1 (Training) | | | | |
| Indirect Fire Control Officer | 02 | FA | 1 | |
| Indirect Fire Control NCOIC | E6/E7 | 13E | 1 | |
| FIST | TOE | TOE | TOE | |
| Firing Data Collector | E3/E4 | 13B | 2 | |
| Battery FDC Team | TOE | TOE | TOE | |
| Impact Data Computer | E3/E4 | 13E | 2 | |
| Fire Markers | E5 | 13F | 2 | |
| Flash Base NCOIC | E6 | 82C | 1 | |
| Flash Base Operators | E4/E5 | 82C | 3 | |
| Section, 155mm Howitzer (SP) M109A1 | TOE | TOE | TOE | |
| Driver, ¼-ton | E3/E4 | IMMAT | 6 | |
| Phase 2 (Execution) | | | | |
| All Phase 1 Personnel plus | | | | |
| Howitzer Battery, 155mm Howitzer (SP), M109A1 | TOE | TOE | TOE | |

2. Equipment

| Type | Quantity | Phase |
|---|---|---|
| Truck, ¼-ton with AN/VRC-47 | 1 | Both |
| Truck, ¼-ton with AN/VRC-46 | 6 | Both |
| Track, M577 with AN/VRC-49 | 1 | Both |
| Radio, AN/PRC-77 | 2 | Both |
| Gunners' Quadrant | 2 | Both |
| Telephone, TA 312/PT | 5 | Both |
| FDC Equipment Set | 1 | Both |
| FIST Equipment Set | 1 | Both |
| Flash Base Equipment (4 OPs) Set | 1 | Both |
| Howitzer, 155mm (SP), M109A1 with equipment | 1 | Phase 1 |
| Howitzer Battery, 155mm Howitzer (SP), M109A1, TOE set | 1 | Phase 2 |
| Calculator, hand held, TI-59 | 2 | Both |
| Binoculars, 7 x 50 | 1 pr. | Both |
| B C Scope | 1 | Both |
| Compass, M2 | 2 | Both |

3. Ammunition:

| | |
|---|---|
| Artillery Ground Burst Simulator | 133 |
| Grenade, Smoke White | 15 |
| Pot, Smoke HC | 5 |

4. Training Area: Non-firing training area, 3 by 9 kilometers.

5. Special Pretest Training. Will be conducted by ARI/HSR.

6. POL Supplies: To be determined.

7. Additional Resource Requirement:

2 radio frequencies

mess facilities/rations for all personnel in field.

## COMMUNICATIONS NETS

1. **FIST, FDC, Firing Battery**: See unit SOP.

2. **Controllers**:

   a. **Radio**

   (1) **Fire Marker Net***: FMCC (net control): AN/VRC-49
   Fire Markers (2): AN/VRC-46
   FIST Researcher: AN/VRC-47

   (2) **Flash Base Net****: FMCC (net control): AN/VRC-49
   Flash Base OP's (3): AN/VRC-46

   (3) **Tactical Fire Support Net****: FMCC (monitor only): AN/PRC-77

   (4 (4) **Research Staff Coordination Net***: FMCC AN/VRC-49
   FIST Researcher AN/VRC-47
   FB Researchers AN/VRC-46

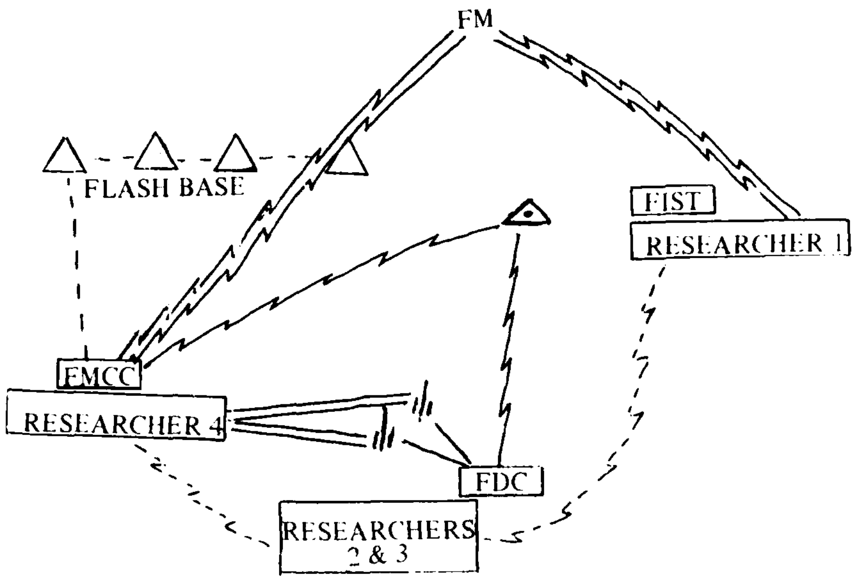
   b. **Wire**

   (1) **Gun Controller Loop**: Howitzers (6): Telephone TA-1/PT or TA-312/PT
   FMCC: Telephone TA-312/PT

   (2) **Flash Base Loop**: Flash Base OP's (3): Telephone TA-312/PT

*additional frequency required

**use unit CEO1 assigned frequency




Tactical fire support radio net
Internal firing battery wire net
Control system gun controllers wire loop
Control system fire marker controller net
Research staff coordination net
Flash base internal wire loop or radio net

**Figure 5**
**Test Communicatons Nets**

## APPENDIX C

## TRAINING PROGRAM

TAB 1: Training Schedule

TAB 2: Lesson Plan for Introductory Briefing to All Participants

TAB 3: Lesson Plan for Gun Controllers

TAB 4: Lesson Plan for Fire Marker Control Computers

TAB 5: Lesson Plan for Fire Markers

## TAB 1

## TRAINING SCHEDULE

The Training Schedule was prepared by the research staff before the exercise. It was conducted as stated with the following modifications:

- Wire nets were not established the day before as it was determined that this could be done during occupation of position.
- All training on T&1 took place in the field.
- Remedial Training consisted of pilot test exercises until 1000, when it was determined that both the IFSCS and the research data collection system were functioning smoothly enough to go into mission exercises.
- Mission Exercises were completed by 1400 on T&4 and debriefings were held during the remainder of that day.

## ANNEX B
## TRAINING SCHEDULE

| Date & Time | Activity | Responsible Individual | Place | Personnel | Equipment |
|---|---|---|---|---|---|
| T-Day | | | | | |
| 0800 0900 | Coordination meeting | Dr. Stein | Bn HQ | Research staff, unit Cdr and staff | None |
| 0900 1600 | Terrain Preparation | Dr. Sevilla | Range | Research staff | 3 each, ¼ ton truck with AN/VRC-46 radios |
| 1300-1600 | Establish Flash Ba: | Mr. Seed | Range | Mr. Seed, Flash Base Personnel | Flash Base Equipment |
| 1300 1600 | Establish wire nets | Mr. King | Range | Bn wire | Wire laying equipment |
| 1600 1630 | Briefing to all participating troops | Dr. Stein | Bn HQ | All | Vu-graph |
| T+1 | | | | | |
| 0800 1200 | FMCC training | Mr. King | Battery Area | Fire Marking Computers | FDC Equipment, TI-59 calculator, FMCC records |
| 0800 1200 | Gun Controller training | Dr. Sevilla | Gun Park | Gun Controllers | M109 A1 Howitzer with crew and telephone |
| 0800-1200 | Flash Base/Fire Marker Training | Mr. Seed | Range | Flash Base personnel, Fire Markers | Flash Base Equipment, Pyrotechnics, 3 ¼ ton trucks with AN VRC-46 radios |
| 1300 1630 | Control System Drill | Dr. Stein | Range | All of above | All of above plus M577 and all Commo equipment |
| T+2 | | | | | |
| 0800 1200 | Remedial Training | As needed | As needed | As needed | As needed |
| 1300 1630 | Pilot Test Exercises | Dr. Stein | Range | All | All |

## ANNEX B
## TRAINING SCHEDULE

| Date & Time | Activity | Responsible Individual | Place | Personnel | Equipment |
|---|---|---|---|---|---|
| T+3 | | | | | |
| 0800–1630 | Offensive mission exercises | Dr. Stein | Range | All | All |
| T+4 | | | | | |
| 0800–1200 | Offensive mission exercises | Dr. Stein | Range | All | All |
| 1300–1630 | Defensive mission exercises | Dr. Stein | Range | All | All |
| T+7 | | | | | |
| 0800–1630 | Defensive mission exercise | Dr. Stein | Range | All | All |
| T+8 | | | | | |
| 0800–1630 | Debriefings | Dr. Stein | Battery Area | Selected personnel | None |

- Coordination meeting: The research staff will meet with the Battalion Commander and those subordinate commanders and staff officers who are involved in the conduct or support of the test. Each projected activity and the requirements for that activity will be reviewed to insure that all requirements will be met or to initate action to meet them.

- Terrain Preparation: The research staff will conduct a terrain reconnaisance to select specific targets, OP's, battery centers and FMCC locations.

- Establish Flash Base: Priority will be given to locating the flash base OP in the morning, so that the flash base crews will be able, during the afternoon, to clear lines of sight, run any necessary survey and establish communications.

- Establish wire nets: Priority will also be given to locating the battery centers and FMCC locations so that the wire lines from the gun position areas to the FMCC locations can be installed in the afternoon.

- Briefing to All Participating Troops: All personnel participating will be assembled and the purpose and method of conduct of the test will be explained to them.

- FMCC Training: Personnel designated to act as fire marker control computers will be taught the manual and handheld calculator methods of determining where a mission should be marked, procedures to direct a fire marker there and the records to be maintained.

- Gun Controller Training: Personnel designated to act as gun controllers will be taught the procedures for determining and reporting the piece and ammunition settings that would have been fired. (This training may not require the full time allotted and these personnel may be released early.)

- Flash Base/Fire Marker Training: This training will have the triple purpose of (1) acquainting the fire markers with the procedures for marking and reporting the effects of simulated fires, (2) familiarizing them with the area in which the fires will be marked and (3) drilling the flash base in triangulation procedures for locating the fires.

- Control System Drill: This will exercise all elements of the control system plus the flash base and research staff, in the absence of the firing battery. The one gun crew will be given dummy fire orders which will be marked and data recovered as if it were in response to an actual fire mission.

- Remedial Training: This period is set aside for such corrective training or training in revised methods, as may have appeared necessary as a result of the Control SystemDrill. (To the extent that this time is not utilized by the research staff, it will be available to the unit commander.)

- Pilot Test Exercises: These will be "all up" "walk through" exercises with FIST, FDC and firing battery present. They are for the purpose of ironing out procedures within and between the artillery systems, control systems and the research staff.

- Offensive Mission Exercises: See Test Design Plan and Detailed Test Execution Annex.

- Defensive Mission Exercises: See Test Design Plan and Detailed Test Execution Annex.

- Debriefings: See Test Design Plan and Detailed Test Execution Annex.

## TAB 2

## LESSON PLAN

## BRIEFING TO ALL TEST PARTICIPANTS

**Objective:** Orientation of all personnel on the goals and outline of the test.

**Time:** 30 minutes

**Training Aids:** Butcher paper, easel and pen

**Outline:** Introduce Dr. Stein of ARI (same outfit as the field unit at Fort Knox, does research and development, among many things, in training methods) who will be assisted by: Dr. Sevilla, Mr. King and Mr. Seed (contractor employees of HSR).

Purpose of Test: To check out a way of putting the whole artillery into engagement simulation training exercises.

What is engagement simulation?

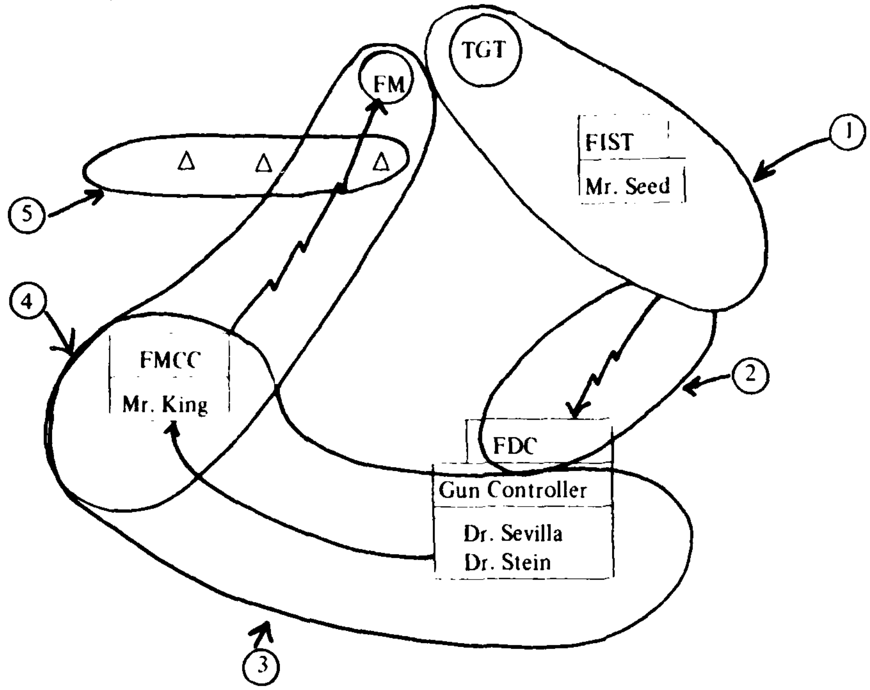
- Describe traditional FTX-umpire judgment no real play of indirect fire.
- ES, by several methods who has heard of REALTRAIN or SCOPES? corrected this for direct fire in small unit exercises.
- Describe MILES.

  - Makes large unit exercise possible, where real artillery support, whole FIST, maybe eventually FSSC comes into it.
  - Need to play entire artillery system.
  - Forces realistic fire planning.
  - Makes fires reflect performance of entire system, i.e., your mistake, if you make any.
  - Artillery training in response to real exercise requirements.

How are we going to do it?

- Tomorrow we will train those of you who will operate the system.
- Then, the next 3 or 4 days, no more than that, we hope, we will exercise it, fine tune it
- Then, last day, we will be interviewing or giving questionnaires to see if it worked.
- What does "worked" mean? Simply, how well did it train this unit.

Here in the system we will use–(draw on butcher paper in numbered steps)




1. The FIST team is here in a maneuver area, as if supporting a company exercise. Mr. Seed will set the scenario and assign them missions.

2. The mission will be processed by the FDC and dry fired as if it were real.

3. A gun controller–one of your 13B soldiers–will measure what would have been fired, not necessarily commanded, and send that to a Fire Marker Control Center (FMCC). Dr. Sevilla and Dr. Stein will be checking the time and accuracy of this.

4. FMCC, a couple of 13E's, will figure out where that data mean the fire would have hit and send a fire marker–one of your 13F's–to that location where he will set off an artillery simulator and, if there were any troops there, would have assessed casualties. Mr. King will be watching how the FMCC works.

5. He will also alert the flash base, which will triangulate the burst, and Mr. Seed will get the time, so that we will have a record of the whole sequence and be able to tell what works well and what doesn't.

Most importantly, does the unit get training out of it, and does it really cause the fire support that the maneuver unit gets to be what you would have shot. That's what we are after.

## TAB 3

## GUN CONTROLLER

| | |
|---|---|
| **Type:** | Conference, Demonstration, Practical Exercise |
| **Time Allotted:** | Four hours |
| **Presented to:** | Gun Controllers |
| **Tools, Equipment, Materials:** | Howitzer, M109A1<br>Telephone, TA/312<br>Inert Ammunition |
| **Personnel:** | Primary Instructor<br>Howitzer Crew |
| **Instructional Aids:** | None |

### 1. INTRODUCTION

The purpose of this class is to familiarize you with the duties and responsibilities of gun controllers. You will first learn to operate as a controller on the howitzer. Later, you *will practice with the other elements* of the control system, the Fire Marker Control Center (FMCC) and the fire markers. You will then participate in a field exercise with the entire control system and a firing battery.

### 2. EXPLANATION

a. The fire request and delivery system:

(1) The fire request: FIST to FDC.
(2) The fire command: FDC to howitzer.
(3) The delivery of fire: howitzer. Any errors in the other two steps, e.g., FIST misplot, FDC miscalculation, result in a wrong command to the howitzer. Errors by the howitzer crew may compound or compensate for previous errors. Whatever the howitzer crew puts on the ammunition and the piece, i.e., charge, fuze, deflection and quadrant elevation (QE) determines where the projectile will land. Your job is to detect those settings and report them to FMCC so that the impact of the projectile can be accurately simulated.

b. The control system:

(1) Gun controller: Reports charge, fuze, deflection and QE actually set on the ammunition and on the piece to FMCC.

(2) FMCC: Converts these settings to a location on the ground and directs a fire marker to that location.

(3) Fire marker: Goes to location and detonates appropriate simulator (HE or smoke). Assesses casualties.

c. The research group:

(1) FIST/Fire Marker. Identifies target to FIST. Measures total time of mission.

(2) Gun researchers. Checks controller accuracy. Measures time delay caused by controller.

(3) FMCC. Checks FMCC procedures. Measures time delay at FMCC.

(4) Flash base–checks fire marker accuracy.

## 3. DEMONSTRATION

Instructor will demonstrate:

a. Physical position of controller in howitzer.

b. How to connect telephone to wire line.

c. How to check and report:

(1) Charge.
(2) Fuze.
(3) Deflection.
(4) QE.
(5) Method of fire.

## 4. PRACTICAL EXERCISE

Instructor will act as FDC and give fire orders to howitzer crew. Crew will execute commands, with deliberate errors introduced at instructor order. Gun controllers wil 'ieck and report settings.

## 5. SUMMARY

The data you collect and report determine where the impact of the projectile will be simulated. Your job is important–it must be done accurately and quickly.

## TAB 4

## LESSON PLAN, FIRE MARKER COMPUTERS

**Objective:** To enable MOS 13E qualified fire direction personnel to operate a Fire Marker Control Center.

**Time:** 3 hours

**Training Aids:** Complete set of manual fire direction center equipment, 1 per student

Hand-held programmable calculator, Model TI-59 with Artillery Module, 1 per student

Program cards for TI-59, 1 set

Chalkboard or butcher paper and easel, chalk or pens

Map, 1/25,000 preferred, 1/50,000 acceptable, 1 per student

Chart table, 1 per student

FMCC Computer Records for manual and calculator method, 3 of each per student

Calculator instructions and job aid, 1 set per student and instructor

**Outline:**

Introduction

- Describe engagement simulation using REALTRAIN and SCOPES
- Concentrate on how artillery is played in these and the reasons for doing so
- Describe the changes introduced by MILES and how they permit greater participation by the artillery
- Concentrate on the training advantages of this greater participation:
  - More thorough training of fire support coordination personnel
  - More realism
  - Training opportunity for artillery troops

- Lead into need for a control mechanism to make it work. This mechanism must do three things:

  - Find out what settings would have been on the piece when fired if live ammunition were used.
  - Find out where that ammunition would have hit
  - Cause the effect to be marked and casualties to be assessed at that location

- You are the middlepoint of that linkage

Objectives

As a result of this training, you will be able, using a TI-59 hand-held programmable calculator or a manual FDC set, to convert gun data (charge, deflection, quadrant, elevation) into grid coordinates of the point of impact and to get the instructions to mark it and assess casualties out to a fire marker; and do all this in less than two minutes. You will also be able to maintain the necessary records.

Sequence of Events (pass out
FMCC computer records)

- Hear fire request on tactical F net

- Direct a fire marker to the closest reference point

- Complete first part of computer record

- When gun data is received:

  - Complete second part of computer record
  - Calculate the burst point and fire marker directions to it
  - Send instructions to fire marker
  - Complete third part of computer record

- When fire marker reports marking of fire, complete fourth part of computer record

Manual Calculation of Burst Point

- Set up firing chart (write on board)

  - Lower left corner is 9085
  - Battery is at 00740-87171, azimuth 5200, altitude 221 meters
  - Plot reference points

- A: 9533-8981
- B: 9462-8980
- C: 9465-8922
- D: 9482-8880

- Set up GFT (write on board): Charge 5GB, chart deflection 3193, chart range 6659, adjusted deflection 3206, adjusted elevation 353.

- Announce sample mission data (have students complete heading of computer record) "Adjust Fire, Grid 947-903, Infantry Squad digging in."

  - Have students determine reference point to use (B) send message to fire marker
  - Have students complete first part of computer record

- Announce sample gun data: "One round, shell HE, charge 5GB, fuze quick, deflection 3230, quadrant 364."

  - Students determine trial range (6810)
  - Students determine chart deflection (3216)
  - Students plot impact and determine altitude from 1/50,000 map at that grid (9445-8960, altitude 210 meters). Point out that if we had a 1/25,000 map, we would have used that as a firing chart and read the altitude directly.
  - Students compute site (-2)
  - Students determine actual range (6840) and grid of burst (9443-8962)
  - Students determine, using target grid and mil/degree conversion scale, direction and azimuth for fire marker (233$^{o}$, 280 meters)
  - Students send message to fire marker and complete 3rd part of computer record. (Note that second part was completed as a work sheet while doing above steps.) Fire marker reports no effect and students complete fourth part of computer record.
  - Point out to students that battery evidently fired out. Lead them to discovery that deflection should have been 3130.

- Message from Observer: "Direction 5400, Right 800 and get your head out." Students complete first part of computer record.

- Gun data charge 5GB, Fz Q, deflection 3123, quadrant 358

- Have students process this as above, directing fire marker from previous round

- Message from observer: "Add 100, Fire for Effect" (Have students direct gun controller to No. 1 piece)

- Gun Data: "Battery one round, charge 5GB, Fuze VT, deflection 3125, quadrant 367"

- Students process this data. Fire marker reports three infantry casualties assessed, and squad withdrawing. Observer gives end of mission.

TI-59 Calculation of Burst Point

- Pass out instruction sheet and job aids

- Follow instruction sheet to initialize calculator with same data as for manual method. (Note that this gives range K of 1.02).

- Go through the same mission with the calculator. Points to note:

  - Calculator will give slightly different grid. This reflects difference between calculator and manual FDC solutions.
  - Altitude must be read off map based on observer target location. This may require a recheck when it is obvious that a gross error has been made.

- Spend remainder of time in drill of both methods.

TAB 5

# FIRE SUPPORT TEAM (FIST), FIRE MARKER, AND FLASH BASE PARTICIPATION IN ENGAGEMENT SIMULATION TRAINING

| | |
|---|---|
| **Type:** | Lecture, Demonstration, and Application |
| **Time Allotted:** | Four Hours |
| **Presented to:** | Participating Fire Support Teams, Fire Markers, and Flash Base Personnel |
| **Tools, Equipment and Materials** | **FIST**– Binoculars, Compasses, Maps, Associated FO Equipment, ¼ Ton Truck with AN/VRC-46 Radio.* |
| | **Fire Markers**– Compasses, Maps, Two ¼ Ton Trucks with AN/VRC-46 Radio* |
| | **Flash Bases**– Flash Base Equipment, Four ¼ Ton Trucks with AN/VRC-46 Radios.* |
| | **Instructor**– Map with Overlay, BC Scope, Binoculars, Pyrotechnics |
| **Personnel:** | Primary Instructor–FIST<br>Researcher |
| **Instructional Aids:** | Chalkboard with Chalk (or Equivalent) |
| | * or Equivalent Communications Capability |

## I. INTRODUCTION

A. **Gain Attention.** The objective of all military training is success in combat. The objective of Engagement Simulation (ES) is to make that training as close to actual combat as possible. The Army has long realized that success on the battlefield comes from the effective employment of supporting arms, particularly artillery. Unfortunately . . . the details of coordinating and employing that fire power have often been lost in the "big picture" of tactical training. The FIST, as the eyes, ears, and in many ways the "mouth" (advocate) of those supporting arms, is the keystone to success both in combat and in training.

B. **Motivate.** We, and that's a big "we"--you, I, Human Sciences Research (HSR), The Army Research Institute for the Behavioral and Social Sciences (ARI), all working on a project sponsored by TRADOC Systems Manager, Tactical Engagement Simulation (TSM-TES) - are here this week to bring artillery to ES. The procedures that we develop and test will be the basis for all such training throughout the Army. I would like you to consider this as much your project as it is ours. We will be looking for your ideas, comments and suggestions. The greatest training ideas in the world are useless if they don't work right here, at your level.

C. **State Purpose and Main Ideas.** What do I need from you? That's easy—be professional; get snapped in on this phase of ES development; and then perform your respective job to the best of your ability. I would ask you also to be flexible; it will go wrong some of the time, and slowly much of the time. Our final goal is to produce the best possible training vehicle. We will be ironing out procedures in the Fire Direction Center (FDC), on the guns, in the Fire Marker Control Center (FMCC), and with the FIST, flash bases, and fire markers out in the maneuver area.

By the end of this period of instruction, you should be able to:

(1) Explain briefly the procedure by which firing battery ES training methods will be developed and tested during this field exercise.

(2) Describe your respective functions in ES training.

(3) Describe your respective functions with regard to testing and evaluating the test design plan itself during and after this field exercise.

(4) In the case of the fire markers, safely and effectively employ artillery simulators and other pyrotechnics.

(5) Operate effectively in designated training areas.

## II. PRESENTATION

A. **The Firing Battery and ES Training.** The overall pupose of this test is to incorporate the firing battery into ES training. During this test, there will be three levels of participation, with one of you in each, as follows: (Note: Use Diagram. See Enclosure 1.)

1. **ES Participants.** These are those firing battery personnel who are performing their normal tactical missions; i.e., those who will be evaluated during normal ES training. (Note: Represented on diagram by circles.) These include FIST, FDC, and the guns.

2. **ES Controllers.** These are those trained support personnel that would control and evaluate the ES participants during normal ES training. (Note: Represented on diagram by rectangles.) These include gun controllers, FMCC personnel, and fire markers.

3. **Researchers and Support Personnel.** These are the researchers and other support personnel that are involved in evaluating the artillery ES training test design plan itself; i.e., those who would not be involved once the developed procedures hit the field. (Note: Represented on diagram by triangles.) These include the HSR/ARI researchers, the flash bases, and associated support personnel.

B. **FIST and Fire Marker Participation in ES.** During normal ES training both the FIST and fire markers participate, as follows:

1. **FIST**

a. Simplistically speaking, the FIST will do its normal job; i.e., the planning and conduct of Fires in support of the ground scheme of maneuver. For the purpose of this test, a researcher will role play the tactical commanders, describe events, identify targets, and assign fire missions.

b. The FIST will be required to prepare offensive and defensive fire plans, and execute them as directed. They will also attack targets of opportunity.

2. **Fire Markers**

a. Fire markers support ES by simulating the effects of artillery fire in the maneuver area. Essentially, they move to a location on the ground, as directed by a fire marker controller, and detonate an appropriate simulator. Unit controllers would then assess casualties based upon the effectiveness of the simulated fire.

b. **Ground-Point Location.** The ultimate success of this entire test depends upon the speed and accuracy with which the fire markers can place their simulators.

(1) **Assumptions.** That fire markers can:

(a) Read a map, and use a lensatic compass.

(b) Operate radio equipment using proper artillery procedures and terminology.

(c) Traverse the exercise terrain quickly and efficiently.

(2) Fire markers will receive target or burst location in one of two ways.

(a) Grid coordinates; e.g., "grid 945927."

(b) Shift from a known (reference) point; e.g., "from reference point green, azimuth 220$^{o}$, distance 400 meters."

C. **FIST, Fire Marker, and Flash Base Participation in the ES Test.** The primary purpose of this field exercise is to test the procedure by which to bring the firing battery into ES training, not to test the proficiency of the battery itself. This places additional responsibilities on all of you since you must perform your normal functions to the best of your abilities, and evaluate the process at the same time.

1. Those of you in the FIST will not be evaluated as such, except to the degree necessary to validate the test design plan. Fire markers will be checked to see how fast and how well you learn and perform your duties. You flash bases will be checking the accuracy of the other two, and the battery as well.

2. **Tactical Considerations.** To you FIST members, the tactical scenario is merely a vehicle by which to present test events. It is not intended to represent "the " or even "a" school solution to attacking or defending the terrain over which we will be operating. Similarly, your tactical decisions will be at issue only if they will adversely affect the outcome of the test. In other words, be realistic, but not overly concerned with the soundness of your tactics. If the researcher modifies one of your decisions, it will be to bring it into line with the next scheduled event.

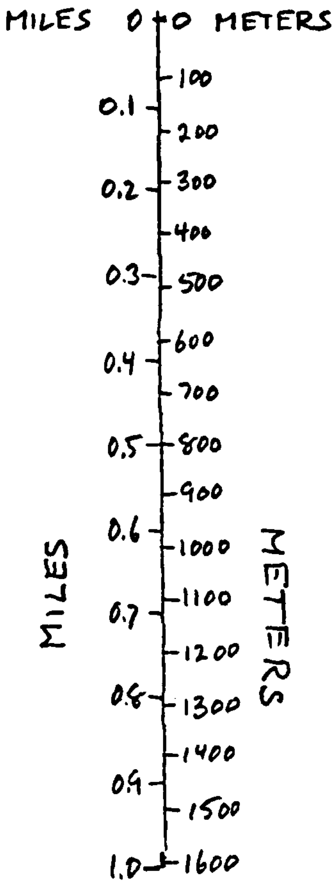
3. **Technical Considerations.** Missions will be conducted using fire markers to simulate bursts in the impact area. The fire markers will be directed to the impact point by the FMCC. The FMCC will have calculated their data from that taken from the guns by the gun controllers. The FIST will then see a pyrotechnic marker detonated at the point at which the guns *are actually trained.* The focus of this entire test lies in that fact; i.e., the accuracy and speed with which all elements of the firing battery are brought into the ES play. In this regard, the following considerations apply:

a. **Mission Summary**

(1) Types of missions–adjust fire (AF) and fire for effect (FFE).

(2) Shells–high explosive and smoke.

(3) Fuzes–quick (Q); mechanical time (MT); variable time (VT).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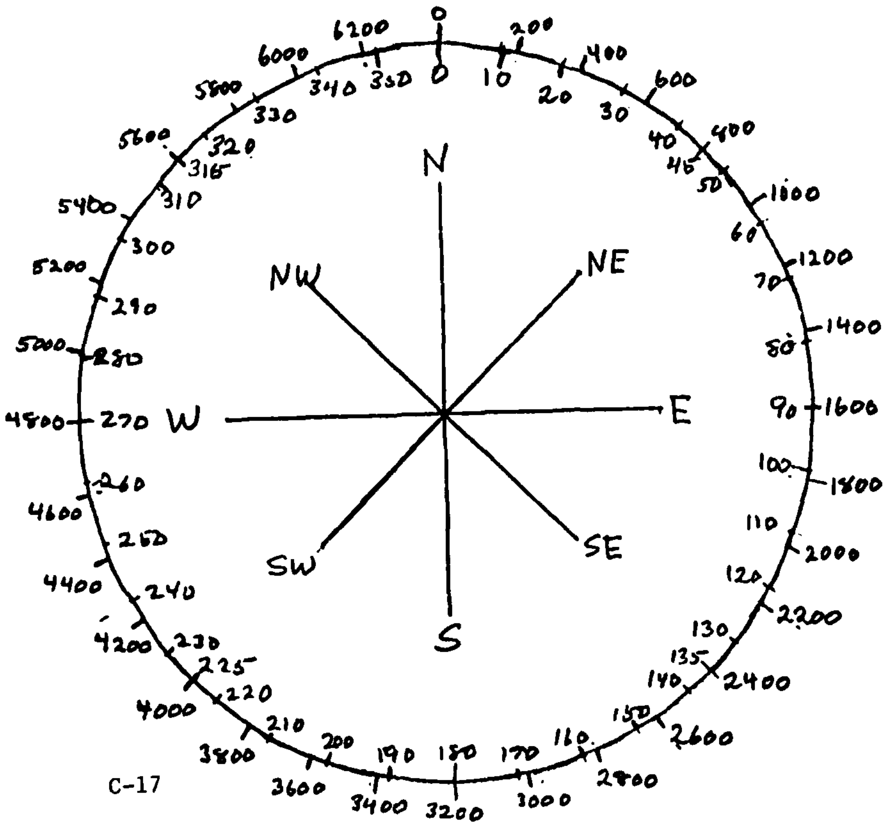
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6000
6200

# APPENDIX D

# FIRE MARKER CONTROL COMPUTER RECORDS

TAB 1: Calculator Computer's Record, Blank and Completed

TAB 2: Chart, GFT and GST Computer's Record, Blank and Completed

## TAB 1



Date ____________ Exercise ____________ Computer ____________

Btry Loc ____________ ____________ Az ____________ Alt ____________

Chg ______ Rg K ______ DF Corr ______ Reg. Rg. ______

Chg ______ Rg K ______ DF Corr ______ Reg. Rg. ______

Tgt Area Alt ______

---

Msn/Rd No. ___ / ___ Fire Marker ____________ Ref Pt ____________

Fire Request (Time Rec'd. ________ ) ____________

Firing Data (Time Fired ________ ) Tgt Alt ____________

No Rds ______ Shell ______ Chg ______ Fz ______ DF ______ Q ______

Fire Marker Data (Time Sent ________ )

No Rds ______ Shell ______ Fz ______ Grid ______ ______

Effect (Time Marked ________ ) Az Dist

---

Msn/Rd No ___ / ___ Fire Marker ____________ Ref Pt ____________

Fire Request (Time Rec'd ________ ) ____________

Firing Data (Time Fired ________ ) Tgt Alt ____________

No Rds ______ Shell ______ Chg ______ Fz ______ DF ______ Q ______

Fire Marker Data (Time Sent ________ )

No Rds ______ Shell ______ Fz ______ Grid ______ ______

Effect (Time Marked ________ ) Az ______ Dist ______

---

Msn/Rd No ___ / ___ Fire Marker ____________ Ref Pt ____________

Fire Request (Time Rec'd ________ ) ____________

Firing Data (Time Fired ________ ) Tgt Alt ____________

No Rds ______ Shell ______ Chg ______ Fz ______ DF ______ Q ______

Fire Marker Data (Time Sent ________ )

No Rds ______ Shell ______ Fz ______ Grid ______ ______

Effect (Time Marked ________ ) Az ______ Dist ______

---

Date ____________ Exercise ____________ Computer ____________

Btry Loc ____________ Az ______ Alt ______

GFT: Chg ______ Ch Rg ______ el ______ df corr ______

Chg ______ Ch Rg ______ el ______ df corr ______

---

Msn/Rd No ___ / ___ Fire Marker ____________ Ref Pt ____________

Date 18 October 79 Exercise ______ Computer SM

Btry Loc 01237 85817 Az 5400 Alt 240

Chg 6 Rg K 988 DF Corr L4 Reg. Rg. 8500

Chg ______ Rg K ______ DF Corr ______ Reg. Rg. ______

Tgt Area Alt 210

---

Msn/Rd No. 13 / 1 Fire Marker #2 Ref Pt #4

Fire Request (Time Rec'd. 1108 ) Adj. Sm. 948900

Firing Data (Time Fired 1111 ) Tgt Alt 210

No Rds 1 Shell HE Chg 6 Fz Q DF 3153 Q 303

Fire Marker Data (Time Sent 1112 )

No Rds 1 Shell HE Fz Q Grid 9476 9001

Effect (Time Marked 1116 ) Az 136 Dist 174

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Msn/Rd No 13 / 2 Fire Marker #2 Ref Pt LR

Fire Request (Time Rec'd 1117 ) L400

Firing Data (Time Fired 1118 ) Tgt Alt 210

No Rds 1 Shell HE Chg 6 Fz Q DF 3167 Q 305

Fire Marker Data (Time Sent 1119 )

No Rds 1 Shell HE Fz Q Grid 9467 8995

Effect (Time Marked 1122 ) Az 234 Dist 116

---

Msn/Rd No 13 / 3 Fire Marker #2 Ref Pt LR

Fire Request (Time Rec'd 1123 ) +200

Firing Data (Time Fired 1125 ) Tgt Alt 210

No Rds ______ Shell HE Chg 6 Fz Q DF 3159 Q 317

Fire Marker Data (Time Sent 1125 )

No Rds 1 Shell HE Fz Q Grid 9464 9012

Effect (Time Marked [illegible] ) Az 334 Dist 817

---

Msn/Rd No. 13 / 4 Fire Marker #2 Ref Pt L.R.

Fire Request (Time Rec'd. 1128 ) L70 -50 SM

Firing Data (Time Fired 1130 ) Tgt Alt 210

TAB 2

Date ____________ Exercise ____________ Computer ____________

Btry Loc ____________ Az ________ Alt ____________

GFT: Chg ________ Ch Rg ________ el ________ df corr ____________

Chg ________ Ch Rg ________ el ________ df corr ____________

Msn/Rd No ______ / ______ Fire Marker ____________ Ref Pt ____________

Fire Request (Time Rec'd ________ ) ____________

Firing Data (Time fired ________ )

No Rds ________ Shell ________ Chg ________ Fz ________ DF ________ Q ________

Trial Rg ________ Tgt Alt ________ VI ________ DF Corr –/+ ________ Site –/+ ________

Fire Marker Data (Time Sent ________ ) Ch DF ________ 20/R– ________

No Rds ________ Shell ________ Fz ________ el ________

Grid ________ ________ Az ________ Dist ________ Ch Rg ________

Effect (Time Marked ________ ) ____________

Msn/Rd No ______ / ______ Fire Marker ____________ Ref Pt ____________

Fire Request (Time Rec'd ________ ) ____________

Firing Data (Time Fired ________ )

No Rds ________ Shell ________ Chg ________ Fz ________ DF ________ Q ________

Trial Rg ________ Tgt Alt ________ VI ________ DF Corr –/+ ________ Site –/+ ________

Fire Marker Data (Time Sent ________ ) Ch DF ________ 20/R– ________

No Rds ________ Shell ________ Fz ________ el ________

Grid ________ ________ Az ________ Dist ________ Ch Rg ________

Effect (Time Marked ________ ) ____________

Msn/Rd No ______ / ______ Fire Marker ____________ Ref Pt ____________

Fire Request (Time Rec'd ________ ) ____________

Firing Data (Time Fired ________ )

No Rds ________ Shell ________ Chg ________ Fz ________ DF ________ Q ________

Trial Rg ________ Tgt Alt ________ VI ________ DF Corr –/+ ________ Site –/+ ________

Fire Marker Data (Time Sent ________ ) Ch DF ________ 20/R– ________

No Rds ________ Shell ________ Fz ________ el ________

Grid ________ ________ Az ________ Dist ________ Ch Rg ________

Effect (Time Marked ________ ) ____________

Computer

Btry Loc 01237 85217 Az 5400 Alt 240

GFT: Chg 6 Ch Rg 8500 el 210 df corr L4

Chg ____ Ch Rg ____ el ____ df corr ____

Msn/Rd No. 36 / 1 Fire Marker #2 Ref Pt #4

Fire Request (Time Rec'd 1144 ) 9506 8944

Firing Data (Time fired 1145 )

No Rds 1 Shell HE Chg 6 Fz Q DF 3194 Q 273

Trial Rg ____ Tgt Alt ____ VI ____ DF Corr -/+ ____ Site -/+ ____

Fire Marker Data (Time Sent 1147 ) Ch DF ____ 20/R- ____

No Rds 1 Shell HE Fz Q 9500 8933 el ____

Grid 9501 8944 Az 171/3040 Dist 69 Ch Rg ____

Effect (Time Marked 1149 )

Msn/Rd No 36 / 2 Fire Marker #2 Ref Pt L R

Fire Request (Time Rec'd 1150 ) R50 FFE

Firing Data (Time Fired 1151 )

No Rds 18 Shell HE Chg 6 Fz Q DF 3186 Q 273

Trial Rg ____ Tgt Alt ____ VI ____ DF Corr -/+ ____ Site -/+ ____

Fire Marker Data (Time Sent 1154 ) Ch DF ____ 20/R- ____

No Rds 18 Shell HE Fz Q 9524 8929 el ____

Grid 9505 8949 Az 34/0605 Dist 59 Ch Rg ____

Effect (Time Marked 1157 )

Msn/Rd No 36 / 3 Fire Marker #2 Ref Pt L R

Fire Request (Time Rec'd 1157 ) L20 +50 RPT

Firing Data (Time Fired 1158 )

No Rds 18 Shell HE Chg 6 Fz Q DF 3183 Q 273

Trial Rg ____ Tgt Alt ____ VI ____ DF Corr -/+ ____ Site -/+ ____

Fire Marker Data (Time Sent ____ ) Ch DF ____ 20/R- ____

No Rds 18 Shell HE Fz Q 9504 8941 el ____

D-5

Grid 4501 8944 Az 94/1671 Dist 43 Ch Rg ____

## APPENDIX E

## TEXT OF SITUATION BRIEFING AND FRAGMENTARY ORDER ISSUED BY FORWARD AREA RESEARCHER TO FIST

### Situation

Gentlemen, I just got back from battalion. The brigade will continue the attack tomorrow morning at first light. This company remains as part of a battalion team, maneuvering as dismounted infantry. B/3/3 remains as our only indirect fire support. FIST, contact them directly for all fire planning and support. Company C is on our left and 2d Battalion is on our right.

The enemy has been withdrawing to the north. They are believed to be fighting a delaying action with platoon-sized strong points. Although essentially light infantry, they are known to have limited long-range direct-fire weapons, and may possibly have light mortars in support. They are, however, believed to be consolidating their strength and may be expected to conduct counter-attacks in our zone of action with up to company-level strength. They are known to have a platoon-size force in the vacinity of our final objective, specifically*.

### Mission

Our mission is to seize, occupy, and defend the high ground to our direct front.

### Execution

The battalion will attack on line with two companies abreast. Company A will pass through Company C and will be on our left flank. Charlie will become the battalion reserve. Our left boundary will run along that treeline and dogleg to the northwest just beyond that treeline. 2d Battalion will be on our right, the right boundary will follow the treeline to the small pond (952 897) and dogleg to the northwest.* We will attack with the platoons abbreast, 1st on the left, 2d on the right. The 3d will maintain covering fires from their present positions until I call them forward.

FIST, we have time to work a detailed fire plan for this one. Get your targets planned and get them and your overlays back to B/3/3 sometime this afternoon. I want

*Areas pointed out on ground to FIST leader.

some preplanned missions on ____________*____________. I am worried about observation from ________*______ and ______*________. Plan some on-call smoke missions in both of those areas. I also want a preplanned smoke mission in that treeline*, to be established before jump off across this clear area to our front. I also want to prep our final objectives. Make it on-call. Also plan some fires on likely avenues of approach into our final objective. Don't forget that counter-attack capability. Otherwise fire planning as usual.

FIST leader, you come with me, I will be with the 2d Platoon. I also want one of you observers to be with the lead elements of that platoon .

Any questions?

*Areas pointed out on ground to FIST leader.

## APPENDIX F

## DATA TABLES

TAB 1: Time Intervals

TAB 2: Fire Marker Speed

TAB 3: Fire Marker Accuracy

## TAB 1

## TIME INTERVALS

| Mission/ Shot No. | Forward Observer Time | Fire Direction Center Time | Gun Time | Artillery System Time | Gun Controller Time | Fire Marker Control Center Time | Fire Marker Time | Control System | Total Time |
|---|---|---|---|---|---|---|---|---|---|
| 1/1 | (1) | (2) | :28 | (1) | :13 | 2:14 | 9:00 | 11:27 | (1) |
| 2/1 | :53 | 1:10 | :18 | 2:21 | :08 | 2:06 | 2:52 | 5:06 | 8:27 |
| 2/2 | :10 | 1:00 | 1:11 | 2:21 | 1:31 | 1:40 | 2:00 | 5:11 | 7:32 |
| 3/1 | :14 | 1:42 | :42 | 2:38 | :29 | 2:43 | 3:15 | 6:27 | 9:05 |
| 4/1 | 1:22 | 1:28 | :31 | 3:21 | 1:09 | 1:00 | 3:58 | 6:07 | 9:20 |
| 4/2 | :32 | :37 | :37 | 1:46 | :26 | :55 | 4:16 | 5:37 | 7:23 |
| 4/3 | 1:01 | :26 | :30 | 1:57 | :35 | 1:15 | 3:34 | 5:24 | 7:21 |
| 4/4 | :53 | :33 | :22 | 1:48 | 1:20 | 1:20 | 4:25 | 7:05 | 8:43 |
| 5/1 | 1:25 | 1:36 | :16 | 3:17 | :33 | 1:06 | 1:54 | 3:33 | 6:50 |
| 5/2 | :44 | 1:26 | :50 | 3:00 | :30 | 1:16 | 1:59 | 3:45 | 6:45 |
| 6/1 | 3:24 | 3:24 | :58 | 7:46 | :27 | 1:30 | 5:20 | 7:17 | 15:05 |
| 6/2 | (1) | (2) | :48 | (2) | :23 | (3) | 2:05 | (1) (3) | (1) (3) |
| 6/3 | :13 | 1:18 | 1:22 | 2:27 | :44 | 1:14 | 2:02 | 4:00 | 6:40 |
| 6/4 | :30 | 1:34 | 1:29 | 2:33 | :33 | 1:13 | 2:58 | 4:44 | 7:47 |
| 7/1 | :12 | (2) | (4) | (4) | (4) | 1:09 | 1:11 | (4) | 4:42 |
| 8/1 | 2:15 | :27 | :18 | 3:00 | (3) | (3) | 4:44 | (3) | (3) |
| 9/1 | 2:55 | 3:20 | :52 | 7:07 | :56 | 1:00 | 2:48 | 4:44 | 11:51 |
| 9/2 | :54 | 1:35 | :18 | 2:47 | :37 | 1:20 | 1:20 | 3:17 | 6:04 |
| 9/3 | 1:27 | :45 | :23 | 2:35 | 2:38 | 1:17 | 1:50 | 5:45 | 8:20 |
| 9/4 | (1) | (2) | :38 | 3:18 | :46 | 1:36 | 1:57 | 4:19 | 7:37 |
| 10/2 | (1) | (5) | :03 | (1) (5) | :49 | :49 | 1:34 | 3:12 | (1) (5) |
| 11/1 & 2 | 1:41 | :04 | 2:04 | 3:49 | (6) | (6) | 8:30 | (6) | (6) |
| 11/3 | :23 | :21 | :17 | 1:01 | :28 | 1:12 | 3:55 | 5:35 | 6:36 |
| 11/4 | :24 | :16 | (4) | (4) | (4) | :56 | 1:53 | (4) | 5:16 |
| 12/1 | 1:10 | :34 | :45 | 2:29 | :31 | 1:25 | 2:41 | 4:37 | 7:06 |
| 12/2 | (1) | :58 | :15 | (1) | :13 | :57 | (7) | (1) (7) | (1) (7) |
| 13/1 | (1) | 2:00 | (4) | (4) | (4) | 1:06 | 3:18 | (1) (4) | (1) |
| 13/2 | :21 | 1:33 | :21 | 2:15 | :24 | 1:06 | 2:25 | 3:55 | 6:10 |
| 13/3 | :38 | :44 | :28 | 1:50 | :16 | 1:10 | 2:17 | 3:43 | 5:33 |
| 13/4 | 1:11 | 1:22 | :26 | 2:59 | :12 | 1:13 | 1:44 | 3:09 | 6:08 |
| 13/5 | 1:35 | 1:40 | :23 | 3:38 | :07 | 1:13 | 1:42 | 3:02 | 6:40 |
| 14/1 | 1:29 | (3) | (3) | (3) | (3) | 1:16 | 6:21 | (3) | (3) |
| 14/2 | :37 | 1:33 | :14 | 2:24 | :17 | :57 | 4:37 | 5:51 | 8:15 |
| 14/3 | :03 | 1:47 | :23 | 2:13 | :22 | 1:10 | 3:41 | 5:13 | 7:26 |
| 14/4 | :31 | 1:19 | (4) | (4) | (4) | 1:00 | 2:04 | (4) | 6:15 |
| 14/5 | :16 | 1:28 | :42 | 2:26 | 1:01 | 1:22 | (8) | (8) | (8) |

| Mission/ Shot No. | Forward Observer Time | Fire Direction Center Time | Gun Time | Artillery System Time | Gun Controller Time | Fire Marker Control Center Time | Fire Marker Time | Control System | Total Time |
|---|---|---|---|---|---|---|---|---|---|
| 15/1 | :32 | 4:15 | :53 | 5:40 | :19 | 3:48 | 5:41 | 9:46 | 15:26 |
| 15/2 | :27 | 1:14 | :30 | 2:11 | :19 | 1:00 | 3:10 | 4:29 | 6:40 |
| 16/1 | 1:55 | 2:34 | :31 | 5:00 | :05 | 1:21 | 6:55 | 8:21 | 13:21 |
| 16/2 | :14 | 1:03 | :29 | 1:46 | :28 | :55 | 2:30 | 3:53 | 5:39 |
| 17/1 | :10 | 1:55 | :30 | 2:35 | :33 | 1:27 | 1:07 | 3:07 | 5:42 |
| 17/2 | :59 | :10 | :17 | 1:26 | :21 | :56 | :40 | 1:57 | 3:23 |
| 18/1 | :40 | 2:46 | :25 | 3:51 | :25 | 2:43 | 3:06 | 6:14 | 10:05 |
| 18/2 | :30 | 1:57 | (4) | (4) | (4) | 1:45 | 1:10 | (4) | 7:01 |
| 19/1 | 1:07 | 2:09 | 1:37 | 4:53 | :35 | 2:24 | 1:16 | 4:16 | 9:09 |
| 19/2 | (1) | (2) | 1:07 | 4:35 | :34 | (8) | (8) | (8) | (1) (8) |
| 20/1 | 2:10 | 1:20 | 1:03 | 4:33 | 1:19 | 1:30 | 3:24 | 6:13 | 10:46 |
| 20/2 | (1) | (2) | 1:20 | 3:18 | :36 | 1:59 | 2:38 | 5:13 | 8:31 |
| 20/3 | :05 | 2:14 | :57 | 3:16 | :49 | :45 | 4:17 | 5:51 | 9:07 |
| 21/1 | :51 | :48 | (4) | (4) | (4) | 1:59 | 5:49 | (4) | 10:29 |
| 22/1 | 2:11 | 2:01 | :39 | 4:51 | :18 | 1:00 | 4:17 | 5:35 | 10:26 |
| 22/2 | :05 | 1:03 | :17 | 1:25 | :21 | :43 | 3:04 | 4:08 | 5:33 |
| 23/1 | 1:45 | 1:22 | :55 | 4:02 | 1:07 | (9) | (9) | 5:39 | 9:41 |
| 23/2 | :04 | :27 | :53 | 1:24 | 1:05 | :20 | :10 | 1:35 | 2:59 |
| 24/1 | :56 | :34 | 1:22 | 2:52 | :48 | 1:30 | 1:25 | 3:43 | 6:35 |
| 25/1 | :35 | 1:25 | 1:05 | 3:05 | :29 | (9) | (9) | 2:45 | 5:50 |
| 26/1 | :10 | :25 | :46 | 1:21 | :20 | (9) | (9) | 4:40 | 6:01 |
| 27/1 | :20 | :18 | :39 | 1:17 | :27 | 1:25 | 4:57 | 6:41 | 7:58 |
| 28/1 | 1:48 | :14 | 1:09 | 3:11 | :26 | 2:31 | (8) | (8) | (8) |
| 28/2 | (1) | 1:13 | :26 | (1) | :35 | 2:04 | 3:27 | 6:06 | (1) |
| 28/3 | :25 | 1:27 | :31 | 2:23 | :38 | 1:34 | 6:29 | 8:41 | 11:04 |
| 29/1 | 1:24 | 2:11 | :33 | 4:08 | :23 | 1:03 | 5:44 | 7:10 | 11:18 |
| 30/1 | 1:30 | 1:54 | :31 | 3:55 | :21 | :57 | 2:21 | 3:33 | 7:28 |
| 30/2 | :22 | 1:33 | :17 | 2:12 | :17 | :57 | 1:55 | 3:09 | 5:21 |
| 30/3 | :27 | :45 | :23 | 1:35 | :20 | 1:01 | 2:56 | 4:17 | 5:52 |
| 30/4 | :03 | 1:08 | :28 | 1:39 | 1:27 | 1:00 | :58 | 3:25 | 5:04 |
| 31/1 | :59 | 1:38 | :41 | 3:18 | :32 | 1:06 | 3:59 | 5:57 | 8:55 |
| 31/2 | :19 | :17 | :50 | 1:26 | 1:04 | 1:12 | 3:19 | 5:35 | 7:01 |
| 31/3 | :25 | :42 | :10 | 1:17 | :58 | 1:01 | 2:41 | 4:40 | 5:57 |
| 32/1 | :30 | 1:50 | 1:30 | 3:50 | 1:35 | 1:23 | 7:06 | 10:04 | 13:54 |
| 32/2 | :22 | 1:14 | :35 | 2:11 | :40 | 1:03 | 5:35 | 7:18 | 9:29 |
| 33/1 | 1:38 | :51 | :27 | 2:56 | :25 | 2:21 | (8) | (8) | (8) |
| 33/2 | :43 | :52 | :38 | 2:13 | :30 | :59 | 7:19 | 8:48 | 11:01 |

| Mission/ Shot No. | Forward Observer Time | Fire Direction Center Time | Gun Time | Artillery System Time | Gun Controller Time | Fire Marker Control Center Time | Fire Marker Time | Control System | Total Time |
|---|---|---|---|---|---|---|---|---|---|
| 34/1 | 1:31 | :04 | :38 | 2:09 | :23 | 1:08 | 1:46 | 3:17 | 5:26 |
| 34/2 | :35 | :44 | :17 | 1:36 | 1:08 | 1:30 | :57 | 3:35 | 5:11 |
| 35/1 | :50 | (10) | (10) | 1:27 | :37 | :49 | 1:58 | 3:24 | 4:51 |
| 35/2 | :24 | :54 | :15 | 1:33 | :22 | 1:25 | 3:27 | 5:14 | 6:47 |
| 35/3 | :52 | :08 | :18 | 1:15 | :50 | :50 | 2:36 | 4:16 | 5:34 |
| 36/1 | 1:22 | (3) | (3) | 3:39 | :18 | :51 | 1:27 | 2:35 | 6:15 |
| 36/2 | 1:55 | (3) | (3) | 2:07 | 1:44 | (9) | (9) | 5:52 | 7:59 |
| 36/3 | 1:01 | :13 | .:40 | 2:14 | :30 | 1:11 | 1:33 | 3:14 | 5:08 |
| 36/4 | :19 | :37 | :16 | 1:12 | :25 | 2:10 | :32 | 3:08 | 4:20 |

NOTES: Reasons for Missing Data.

(1) Forward observer time not representative due to research or special training delays.
(2) Time to FDC not representative due to discussions in course of (1) above.
(3) Communications breakdown between gun controller and FMCC.
(4) Gun controller timer moving between guns at event; not able to record time.
(5) Times not representative due to research discussion on treatment of ICM mission.
(6) Times not representative due to administrative discussions and recomputation following very large gunnery error.
(7) Times not representative because correcting a previous fire marker error resulted in an atypically large shift.
(8) Time not representative or fire not marked because fire marker constrained by artificial administrative or research constraints.
(9) FMCC timer did not catch transmission of message to fire marker.
(10) Time not representative due to research discussion on treatment of linear mission.

## TAB 2

## FIRE MARKER SPEED

| Mission/ Shot No. | FM No. | Distance Moved (Meters) | FM Time (Min.:Sec.) | Speed (Meters/Sec) |
|---|---|---|---|---|
| 1/1 | 2 | 287 | 9:00 | 0.53 |
| 2/1 | 2 | 175 | 2:52 | 1.02 |
| 2/2 | 2 | 60 | 2:00 | 0.50 |
| 3/1 | 2 | 211 | 3:15 | 1.08 |
| 4/1 | 1 | 97 | 3:58 | 0.41 |
| 4/2 | 1 | 186 | 4:16 | 0.73 |
| 4/3 | 1 | 60 | 3:34 | 0.28 |
| 4/4 | 1 | 56 | 4:25 | 0.21 |
| 5/1 | 1 | (1) | 1:54 | (1) |
| 5/2 | 1 | (1) | 1:59 | (1) |
| 6/1 | 2 | 155 | 5:20 | 0.48 |
| 6/2 | 2 | 178 | 2:05 | 1.42 |
| 6/3 | 2 | 111 | 2:02 | 0.91 |
| 6/4 | 2 | 89 | 2:58 | 0.50 |
| 7/1 | 2 | 37 | 1:11 | 0.52 |
| 8/1 | 1 | 238 | 4:44 | 0.84 |
| 9/1 | 1 | 139 | 2:48 | 0.83 |
| 9/2 | 1 | 69 | 1:20 | 0.86 |
| 9/3 | 1 | 77 | 1:50 | 0.70 |
| 9/4 | 1 | 47 | 1:57 | 0.40 |
| 10/2 | 1 | 300 | 1:34 | 3.19 |
| 11/1 & 2 | 2 | 267 | 8:30 | 0.52 |
| 11/3 | 2 | 124 | 3:55 | 0.53 |
| 11/4 | 2 | 36 | 1:53 | 0.32 |
| 12/1 | 2 | 485 | 2:41 | 3.01 |
| 12/2 | 2 | 764 | 15:22 | 0.83 |
| 13/1 | 2 | (2) | (2) | (2) |
| 13/2 | 2 | 116 | 2:25 | 0.80 |
| 13/3 | 2 | 217 | 2:17 | 1.58 |
| 13/4 | 2 | 156 | 1:44 | 1.50 |
| 13/5 | 2 | 105 | 1:42 | 1.03 |
| 14/1 | 1 | 336 | 6:21 | 0.88 |
| 14/2 | 1 | 133 | 4:37 | 0.48 |
| 14/3 | 1 | 84 | 3:41 | 0.38 |
| 14/4 | 1 | 55 | 2:04 | 0.44 |
| 14/5 | 1 | (3) | (3) | (3) |

| Mission/ Shot No. | FM No. | Distance Moved (Meters) | FM Time (Min.:Sec.) | Speed (Meters/Sec) |
|---|---|---|---|---|
| 15/1 | 2 | 156 | 5:41 | 0.46 |
| 15/2 | 2 | 65 | 3:10 | 0.34 |
| 16/1 | 2 | 155 | 6:55 | 0.37 |
| 16/2 | 2 | 95 | 2:30 | 0.63 |
| 17/1 | 1 | 58 | 1:07 | 0.87 |
| 17/2 | 1 | 47 | 0:40 | 1.17 |
| 18/1 | 1 | 184 | 3:06 | 0.99 |
| 18/2 | 1 | 35 | 1:10 | 0.50 |
| 19/1 | 2 | 59 | 1:16 | 0.77 |
| 19/2 | 2 | (4) | (4) | (4) |
| 20/1 | 2 | 179 | 3:24 | 0.88 |
| 20/2 | 2 | 109 | 2:38 | 0.69 |
| 20/3 | 2 | 159 | 4:17 | 0.62 |
| 21/1 | 1 | 165 | 5:49 | 0.47 |
| 22/1 | 2 | 300 | 4:17 | 1.17 |
| 22/2 | 2 | 121 | 3:04 | 0.66 |
| 23/1 | 1 | (5) | (5) | (5) |
| 23/2 | 1 | 0 | 0:10 | –– |
| 24/1 | 2 | 82 | 1:25 | 0.96 |
| 25/1 | 2 | (5) | (5) | (5) |
| 26/1 | 2 | (5) | (5) | (5) |
| 27/1 | 2 | 160 | 4:57 | 0.54 |
| 28/1 | 1 | (4) | (4) | (4) |
| 28/2 | 1 | 101 | 3:27 | 0.49 |
| 28/3 | 1 | 69 | 6:29 | 0.18 |
| 29/1 | 1 | 198 | 5:44 | 0.58 |
| 30/1 | 2 | 175 | 2:21 | 1.24 |
| 30/2 | 2 | 53 | 1:55 | 0.46 |
| 30/3 | 2 | 108 | 2:56 | 0.61 |
| 30/4 | 2 | 52 | 0:58 | 0.90 |
| 31/1 | 1 | 141 | 3:59 | 0.59 |
| 31/2 | 1 | 37 | 3:19 | 0.19 |
| 31/3 | 1 | 55 | 2:41 | 0.34 |
| 32/1 | 1 | 373 | 7:06 | 0.88 |
| 32/2 | 1 | 143 | 5:35 | 0.43 |
| 33/1 | 1 | (3) | (3) | (3) |
| 33/2 | 1 | 342 | 7:19 | 0.78 |
| 34/1 | 2 | 115 | 1:46 | 1.08 |
| 34/2 | 2 | 55 | 0:57 | 0.96 |
| 35/1 | 1 | 25 | 1:58 | 0.21 |
| 35/2 | 1 | 62 | 3:27 | 0.30 |
| 35/3 | 1 | 57 | 2:36 | 0.36 |

| Mission/ Shot No. | FM No. | Distance Moved (Meters) | FM Time (Min.:Sec.) | Speed (Meters/Sec) |
|---|---|---|---|---|
| 36/1 | 2 | 89 | 1:27 | 1.02 |
| 36/2 | 2 | (5) | (5) | (5) |
| 36/3 | 2 | 43 | 1:33 | 0.46 |
| 36/4 | 2 | 55 | 0:32 | 1.72 |

(1) Data missing; Fire Marker Control Computer Record incomplete.
(2) Time not representative due to training time for FIST.
(3) Time not representative due to administrative constraint.
(4) Mission not marked due to range constraint.
(5) Fire Marker start time missed.

## TAB 3

## FIRE MARKER ACCURACY

| Mission Shot No. | FM No. | Location Error | Δ Error from Previous Shot (1) | Distance Moved | Cumulative Distance Moved | % Error This Shot | % Error Cumulative |
|---|---|---|---|---|---|---|---|
| 1/1 | 2 | 78.1 | N/A | 287 | 287 | 27.2 | 27.2 |
| 2/1 | 2 | 76.2 | N/A | 175 | 175 | 43.5 | 43.5 |
| 2/2 | 2 | 50.0 | - 26.2 | 60 | 235 | 43.7 | 21.3 |
| 3/1 | 2 | 14.1 | N/A | 211 | 211 | 6.7 | 6.7 |
| 4/1 | 1 | 80.6 | N/A | 97 | 97 | 83.1 | 83.1 |
| 4/2 | 1 | 20.0 | - 60.6 | 186 | 283 | 32.3 | 7.1 |
| 4/3 | 1 | 84.9 | +64.9 | 60 | 343 | 108.2 | 24.7 |
| 4/4 | 1 | 72.8 | - 12.1 | 56 | 399 | 21.6 | 18.2 |
| 5/1 | (2) | (2) | (2) | (2) | (2) | (2) | (2) |
| 6/1 | 2 | 10.0 | N/A | 155 | 155 | 6.4 | 6.4 |
| 6/2 | 2 | 53.9 | +43.9 | 178 | 333 | 24.7 | 16.2 |
| 6/3 | 2 | 98.5 | +44.5 | 111 | 444 | 40.1 | 22.2 |
| 6/4 | 2 | 80.0 | - 18.5 | 89 | 533 | 20.8 | 15.0 |
| 7/1 | 2 | 20.0 | N/A | 37 | 37 | 54.1 | 54.1 |
| 8/1 | 1 | 42.4 | N/A | 238 | 238 | 17.8 | 17.8 |
| 9/1 | 1 | 22.4 | N/A | 139 | 139 | 16.1 | 16.1 |
| 9/2 | 1 | 10.0 | - 12.4 | 69 | 208 | 18.0 | 4.8 |
| 9/3 | 1 | 44.7 | +34.7 | 77 | 285 | 45.1 | 15.7 |
| 9/4 | 1 | 63.2 | +18.5 | 47 | 332 | 39.4 | 19.0 |
| 10/2 | 1 | 20.0 | N/A | 300 | 300 | 6.7 | 6.7 |
| 11/1&2 | 2 | 58.3 | N/A | 267 | 267 | 21.8 | 21.8 |
| 11/3 | 2 | 70.7 | +12.4 | 124 | 391 | 10.0 | 18.1 |
| 11/4 | 2 | 80.6 | + 9.9 | 36 | 427 | 27.5 | 18.9 |
| 12/1 | 2 | 243.1 | N/A | 485 | 485 | 50.1 | 50.1 |
| 12/2 | 2 | 368.9 | +125.6 | 764 | 1,249 | 16.4 | 29.5 |
| 13/1 | (3) | (3) | (3) | (3) | (3) | (3) | (3) |
| 13/2 | 2 | 133.4 | (3) | 116 | 290 | (3) | 46.0 |
| 13/3 | 2 | 53.9 | - 79.5 | 217 | 507 | 36.6 | 10.6 |

| Mission Shot No. | FM No. | Location Error | Δ Error from Previous Shot (1) | Distance Moved | Cumulative Distance Moved | % Error This Shot | % Error Cumulative |
|---|---|---|---|---|---|---|---|
| 13/4 | 2 | 70.7 | +16.8 | 156 | 663 | 10.9 | 10.7 |
| 13/5 | 2 | 44.7 | - 26.0 | 105 | 768 | 24.8 | 5.8 |
| 14/1 | 1 | 58.3 | N/A | 336 | 336 | 17.3 | 17.3 |
| 14/2 | 1 | 140.3 | +82.0 | 133 | 469 | 61.7 | 29.9 |
| 14/3 | 1 | 120.4 | - 19.9 | 84 | 553 | 23.7 | 21.8 |
| 14/4 | 1 | 111.8 | - 8.8 | 55 | 608 | 16.0 | 18.4 |
| 14/5 | 1 | 110.0 | - 1.8 | 43 | 651 | 4.2 | 16.9 |
| 15/1 | 2 | 53.9 | N/A | 156 | 156 | 34.6 | 34.6 |
| 15/2 | 2 | 70.7 | +16.8 | 65 | 221 | 25.8 | 32.0 |
| 16/1 | 2 | 60.8 | N/A | 155 | 155 | 39.2 | 39.2 |
| 16/2 | 2 | 42.4 | - 18.4 | 95 | 250 | 44.6 | 17.0 |
| 17/1 | 1 | 80.0 | N/A | 58 | 58 | 137.9 | 137.9 |
| 17/2 | 1 | 63.2 | - 16.8 | 47 | 105 | 42.1 | 60.2 |
| 18/1 | 1 | 90.5 | N/A | 184 | 184 | 49.2 | 49.2 |
| 18/2 | 1 | 70.7 | - 19.8 | 35 | 219 | 56.6 | 32.3 |
| 19/1 | 2 | 100.0 | N/A | 59 | 59 | 169.5 | 169.5 |
| 20/1 | 2 | 111.8 | N/A | 179 | 179 | 62.5 | 62.5 |
| 20/2 | 2 | 31.6 | - 80.2 | 109 | 288 | 73.2 | 11.0 |
| 20/3 | 2 | 40.0 | + 8.4 | 159 | 447 | 5.3 | 8.9 |
| 21/1 | 1 | 22.4 | N/A | 165 | 165 | 13.8 | 13.8 |
| 22/1 | 2 | 70.7 | N/A | 300 | 300 | 23.7 | 23.7 |
| 22/2 | 2 | 22.4 | - 48.3 | 121 | 421 | 18.5 | 5.3 |
| 23/1 | 1 | 70.7 | N/A | 214 | 214 | 33.0 | 33.0 |
| 24/1 | 2 | 86.0 | N/A | 82 | 82 | 104.9 | 104.9 |
| 25/1 | 2 | (3) | (3) | (3) | (3) | (3) | (3) |
| 26/1 | 2 | 28.3 | N/A | 154 | 154 | 18.4 | 18.4 |
| 27/1 | 2 | 58.3 | N/A | 160 | 160 | 36.4 | 36.4 |
| 28/1 | 1 | (3) | (3) | (3) | (3) | (3) | (3) |
| 28/2 | 1 | 20.0 | N/A | 101 | 101 | 19.8 | 19.8 |
| 28/3 | 1 | 31.6 | +11.6 | 69 | 170 | 16.8 | 18.6 |

| Mission Shot No. | FM No. | Location Error | Δ Error from Previous Shot (1) | Distance Moved | Cumulative Distance Moved | % Error This Shot | % Error Cumulative |
|---|---|---|---|---|---|---|---|
| 29/1 | 1 | 53.8 | N/A | 198 | 198 | 37.8 | 37.8 |
| 30/1 | 2 | 84.9 | N/A | 175 | 175 | 48.5 | 48.5 |
| 30/2 | 2 | 64.0 | - 20.9 | 53 | 228 | 39.4 | 28.1 |
| 30/3 | 2 | 99.0 | +35.0 | 108 | 336 | 32.6 | 29.5 |
| 30/4 | 2 | 86.0 | - 13 | 52 | 388 | 25.0 | 22.1 |
| 31/1 | 1 | 31.6 | N/A | 141 | 141 | 22.4 | 22.4 |
| 31/2 | 1 | 36.1 | - 4.5 | 37 | 178 | 12.2 | 20.3 |
| 31/3 | 1 | 40.0 | + 3.9 | 55 | 218 | 7.1 | 17.2 |
| 32/1 | 1 | 114.0 | N/A | 373 | 373 | 30.5 | 30.5 |
| 32/2 | 1 | 197.2 | +83.2 | 143 | 516 | 58.2 | 38.2 |
| 33/1 | 1 | 136.0 | N/A | 147 | 147 | 92.5 | 92.5 |
| 33/2 | 1 | 53.9 | - 82.1 | 342 | 489 | 24.0 | 11.0 |
| 34/1 | 2 | 41.2 | N/A | 115 | 115 | 35.8 | 35.8 |
| 34/2 | 2 | 85.4 | +44.2 | 55 | 170 | 80.4 | 50.2 |
| 35/1 | 1 | 125.3 (4) | N/A | 25 | 25 | 501.2 (4) | 501.2 (4) |
| 35/2 | 1 | 100.4 | - 24.9 | 62 | 87 | 40.2 | 111.8 (4) |
| 35/3 | 1 | 111.8 | +11.4 | 57 | 144 | 20.0 | 77.6 (4) |
| 36/1 | 2 | 110.4 | N/A | 89 | 89 | 124.0 | 124.0 |
| 36/2 | 2 | 100.4 | - 10.0 | 59 | 148 | 16.9 | 67.8 |
| 36.3 | 2 | 94.3 | - 6.1 | 43 | 191 | 14.2 | 49.4 |
| 36/4 | 2 | 111.8 | +17.5 | 55 | 246 | 31.8 | 45.5 |

NOTES:
(1) "-" denotes a change toward the intended location; i.e., reducing the error.
(2) Data missing; Fire Marker Control Computer Record incomplete.
(3) Mark not observed.
(4) Not considered in computation because caused by gross misunderstanding of instruction by fire marker.

## APPENDIX G
## QUESTIONNAIRE DATA

TAB 1: Summary of Questionnaire Responses

TAB 2: Questionnaires with Numbers of Responses Entered

Inclosure A: All Personnel, Pre- and Post-Test

Inclosure B: E-4 and Above, Pre- and Post-Test

Inclosure C: C/S, Gunners and Assistant Gunners

Inclosure D: FDC Personnel

## TAB I
### Summary of Questionnaire Responses

6a. I have learned a lot from field training.

| | x̄ * | s | n |
|---|---|---|---|
| (1) Pre-test, all cannoneers | 5.90 | 2.09 | 21 |
| (2) Post-test, all cannoneers | 5.74 | 1.98 | 23 |
| (3) Pre-test, E-4 and above | 5.89 | 2.02 | 9 |
| (4) Post-test, E-4 and above | 5.44 | 1.89 | 9 |
| (5) Post-test, C/S and gunners | 6.65 | 2.29 | 17 |
| (6) Pre-test, FDC | 4.40 | 2.24 | 5 |
| (7) Post-test, FDC | 4.0 | 2.76 | 5 |

6b. Field training means live fire.

| | x̄ * | s | n |
|---|---|---|---|
| (1) Pre-test, all cannoneers | 3.33 | 2.78 | 21 |
| (2) Post-test, all cannoneers | 3.43 | 2.41 | 23 |
| (3) Pre-test, E-4 and above | 3.11 | 2.73 | 9 |
| (4) Post-test, E-4 and above | 3.22 | 2.30 | 9 |
| (5) Post-test, C/S and gunners | 3.47 | 2.52 | 17 |
| (6) Pre-test, FDC | 3.60 | 2.71 | 5 |
| (7) Post-test, FDC | 5.0 | 2.04 | 5 |

6c. Field traning means hurry up and wait.

| | x̄ * | s | n |
|---|---|---|---|
| (1) Pre-test, all cannoneers | 5.10 | 2.95 | 21 |
| (2) Post-test, all cannoneers | 4.70 | 2.76 | 23 |
| (3) Pre-test, E-4 and above | 5.33 | 2.75 | 9 |
| (4) Post-test, E-4 and above | 4.56 | 2.71 | 9 |
| (5) Post-test, C/S and gunners | 4.35 | 2.68 | 17 |
| (6) Pre-test, FDC | 5.8 | 2.71 | 5 |
| (7) Post-test, FDC | 4.2 | 2.04 | 5 |

6d. My most recent field training was exciting.

| | x̄ * | s | n |
|---|---|---|---|
| (1) Pre-test, all cannoneers | 3.85 | 2.45 | 21 |
| (2) Post-test, all cannoneers | 4.74 | 2.38 | 23 |
| (3) Pre-test, E-4 and above | 3.33 | 2.26 | 9 |
| (4) Post-test, E-4 and above | 4.00 | 2.63 | 9 |
| (5) Post-test, C/S and gunners | 4.47 | 2.48 | 17 |
| (6) Pre-test, FDC | 2.4 | 1.36 | 5 |
| (7) Post-test, FDC | 3.2 | 2.04 | 5 |

*Means are on an 8 point scale, with 8 indicating strong agreement, 1 indicating strong disagreement.

6e. My most recent field training was boring.

| | $\bar{x}$ * | s | n |
|---|---|---|---|
| (1) Pre-test, all cannoneers | 4.09 | 2.47 | 21 |
| (2) Post-test, all cannoneers | 4.00 | 1.95 | 23 |
| (3) Pre-test, E-4 and above | 5.22 | 2.62 | 9 |
| (4) Post-test, E-4 and above | 4.23 | 2.57 | 9 |
| (5) Post-test, C/S and gunners | 3.88 | 2.18 | 17 |
| (6) Pre-test, FDC | 5.8 | 2.56 | 5 |
| (7) Post-test, FDC | 5.4 | 2.58 | 5 |

6f. I really became involved in my most recent field training.

| | $\bar{x}$ * | s | n |
|---|---|---|---|
| (1) Pre-test, all cannoneers | 5.57 | 2.19 | 21 |
| (2) Post-test, all cannoneers | 5.96 | 1.85 | 21 |
| (3) Pre-test, E-4 and above | 4.88 | 2.13 | 9 |
| (4) Pre-test, E-4 and above | 5.11 | 2.08 | 9 |
| (5) Post-test, C/S and gunners | 5.71 | 2.02 | 17 |
| (6) Pre-test, FDC | 3.4 | 2.58 | 5 |
| (7) Post-test, FDC | 4.00 | 2.76 | 5 |

6g. Dry firing exercises are always a waste of time.

| | $\bar{x}$ * | s | n |
|---|---|---|---|
| (1) Pre-test, all cannoneers | 4.66 | 3.04 | 21 |
| (2) Post-test, all cannoneers | 3.74 | 2.66 | 23 |
| (3) Pre-test, E-4 and above | 5.44 | 3.20 | 9 |
| (4) Pre-test, E-4 and above | 5.11 | 2.42 | 9 |
| (5) Post-test, C/S and gunners | 3.82 | 2.43 | 17 |
| (6) Pre-test, FDC | 5.2 | 2.64 | 5 |
| (7) Post-test, FDC | 4.6 | 2.42 | 5 |

8. Did the controllers slow the battery's performance? (1 = a great deal, 8 = not at all)

| | $\bar{x}$ | s | n |
|---|---|---|---|
| (1) All cannoneers | 6.52 | 1.66 | 23 |
| (2) E-4 and above | 6.44 | 1.71 | 9 |
| (3) C/S and gunners | 6.71 | 1.45 | 17 |
| (4) FDC | 4.2 | 2.79 | 5 |

9. Did the controllers slow your crew's performance? (1 = a great deal, 8 = not at all)

| | $\bar{x}$ | s | n |
|---|---|---|---|
| (1) All cannoneers | 7.04 | 1.65 | 23 |
| (2) E-4 and above | 7.56 | 0.83 | 9 |
| (3) C/S and gunners | 7.06 | 1.80 | 17 |

*Means are on an 8 point scale, with 8 indicating strong agreement, 1 indicating strong disagreement.

10. Did the controllers interfere with the performance of your job? (1 = a great deal, 8 = not at all)

| | $\bar{x}$ | s | n |
|---|---|---|---|
| (1) All cannoneers | 7.30 | 1.54 | 23 |
| (2) E-4 and above | 7.67 | 0.67 | 9 |
| (3) C/S and gunners | 7.29 | 1.67 | 17 |
| (4) FDC | 6.4 | 2.73 | 5 |

11. How accurate was the controllers reporting of the gun data? (1 = very poor, 8 = very accurate)

| | $\bar{x}$ | s | n |
|---|---|---|---|
| (1) All cannoneers | 7.04 | 1.23 | 23 |
| (2) E-4 and above | 7.11 | 1.37 | 9 |
| (3) C/S and gunners | 7.35 | 1.08 | 17 |

13. Did the information on the accuracy of the battery's fire make the training any more interesting to you, compared to other non-firing exercises? (1 = not at all, 8 = a great deal)

| | $\bar{x}$ | s | n |
|---|---|---|---|
| (1) All cannoneers | 6.48 | 1.50 | 21 |
| (2) E-4 and above | 6.29 | 1.03 | 7 |
| (3) C/S and gunners | 6.27 | 1.57 | 15 |
| (4) FDC | 4.6 | 3.01 | 5 |

INCLOSURE A

All Personnel Pre/Post, Screened

ENGAGEMENT SIMULATION ARTILLERY QUESTIONNAIRE

GUN BATTERY PERSONNEL

Instructions: The purpose of this questionnaire is to find out how you feel about training in the Field Artillery. It will help us to improve the program so that you can get more out of your field training. We will not attempt to identify you or your unit and the information you provide will be used for research purposes only. Your participation in filling out this questionnaire is voluntary. We appreciate your honest answers.

1. What is your paygrade? *(Circle one.)*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 6 | 4 | 2 | 7 | 2 | | | |
| E-1 | E-2 | E-3 | E-4 | E-5 | E-6 | E-7 | E-8 |
| 7 | 7 | 3 | 6 | 3 | | | |

2. What is your current MOS?

______________________________

3. How many years/months have you been in your current MOS?

______/______
*Years* *Months*

| | |
|---|---|
| Min 0/1 | Min 0/2 |
| Ave 1/10 | Ave 1/11 |
| Max 4/6 | Max 5/2 |

4. How much experience do you have with the M109/M109A1?

| | | |
|---|---|---|
| ☐ 0-3 Months | 6 | 6 |
| ☐ 3-12 Months | 6 | 7 |
| ☐ Over 1 Year | 9 | 10 |

5. What is your job?

______________________________

6. The following questions ask you to agree or disagree with a statement about your training. You may circle any number from 1 (disagree strongly) to 8 (agree strongly) which reflects how you feel about the statement.

*(Circle One.)*

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | a. | I have learned a lot from field training. | | 1 | | 3 | | 6 | 1 | 2 | 8 | |
| | | | Disagree Strongly | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Agree Strongly |
| | | | | 1 | | 3 | 2 | 3 | 6 | 1 | 7 | |
| q | b. | Field training means live fire. | | 9 | 2 | 2 | 1 | 2 | | 1 | 4 | |
| | | | Disagree Strongly | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Agree Strongly |
| | | | | 8 | 2 | 3 | 3 | 2 | 2 | | 3 | |
| | c. | Field training means hurry up & wait. | | 6 | | 1 | | 1 | 3 | 2 | 7 | |
| | | | Disagree Strongly | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Agree Strongly |
| | | | | 6 | 1 | 2 | | 4 | 2 | 2 | 6 | |
| | d. | My most recent field training was exciting. | | 6 | 1 | 2 | 3 | 4 | | 1 | 3 | |
| 1q | | | Disagree Strongly | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Agree Strongly |
| | | | | 3 | 3 | 1 | 3 | 4 | 2 | 3 | 4 | |
| | e. | My most recent field training was boring. | | 6 | 1 | 1 | 5 | 3 | 2 | | 4 | |
| | | | Disagree Strongly | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Agree Strongly |
| | | | | 4 | 1 | 2 | 6 | 6 | 1 | | 2 | |
| | f. | I really became involved in my most recent field training. | | 2 | | 2 | 2 | 5 | 4 | 2 | 6 | |
| | | | Disagree Strongly | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Agree Strongly |
| | | | | 1 | | 2 | 1 | 5 | 2 | 7 | 5 | |
| | g. | Dry firing exercises are always a waste of time. | | 7 | 1 | | | 2 | 3 | | 7 | |
| | | | Disagree Strongly | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Agree Strongly |
| | | | | 9 | 1 | 1 | 3 | 2 | 3 | | 4 | |

*If you are filling out this* questionnaire for the first time, STOP HERE. If you have just finished Artillery Engagement Simulation Training, answer the rest of the questions.

7. What duty position(s) did you hold during these exercises?

- ☐ a. Cannoneer
- ☐ b. Loader
- ☐ c. Gunner
- ☐ d. Communications
- ☐ e. Fuze Setter
- ☐ f. Charge Cutter
- ☐ g. Chief of Section

8. Did the Controllers slow the firing battery's performance?

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| A great deal | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Not at all |
| | | 1 | 1 | 1 | 1 | 6 | 4 | 9 | |

9. Did the Controllers slow your crew's performance?

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| A great | 1 | | | | 2 | 4 | 1 | 15 | Not at |
| deal | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | all |

10. Did the Controllers interfere with the performance of your job?

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| A great | 1 | | | | 1 | 1 | 4 | 16 | Not at |
| deal | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | all |

11. How accurate was the Controllers' reporting of the Gun Data?

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Very | | | | 1 | 1 | 2 | 5 | 14 | Very |
| poor | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | good |

12. Did you receive any information on the accuracy of the Battery's fire?

☐ a. Yes
☐ b. No (Skip the next question.)

13. Did the information on the accuracy of battery's fire make the training any more interesting to you compared to other non-firing exercises?

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Not at | | 1 | | | 4 | 5 | 4 | 7 | A great |
| all | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | deal |

14. Do you have any additional comments about your experiences in this training? Write them below: (grammar and spelling corrected)

- It was all right.
- It was a great start in my MOS.
- Any field exercise gives you more knowledge of your job.
- If anything can be done to improve field training, I'm for it.

Thank you for your cooperation.

- I generally enjoy the field.
- It was educational
- This training added a certain amount of realism to a dry fire exercise.
- A damn good exercise.
- I learned to be a gunner and in the position to take the gunner spot. It taught me a great deal and I am happy with the training.
- I don't like artillery or combat MOS, period.
- I learned alot.

INCLOSURE B

Pre/Post, E-4 and Above, Screened
ENGAGEMENT SIMULATION ARTILLERY QUESTIONNAIRE
GUN BATTERY PERSONNEL

Instructions: The purpose of this questionnaire is to find out how you feel about training in the Field Artillery. It will help us to improve the program so that you can get more out of your field training. We will not attempt to identify you or your unit and the information you provide will be used for research purposes only. Your participation in filling out this questionnaire is voluntary. We appreciate your honest answers.

1. What is your paygrade? *(Circle one.)*

| E-1 | E-2 | E-3 | E-4 | E-5 | E-6 | E-7 | E-8 |
|---|---|---|---|---|---|---|---|
| | | | 7 | 2 | | | |
| | | | 6 | 3 | | | |

2. What is your current MOS?

_______________________________

3. How many years/months have you been in your current MOS?

______/______
*Years* *Months*

| | | |
|---|---|---|
| Min | 1/6 | 2/4 |
| Ave | 2/9 | 3/6 |
| Max | 3/9 | 5/2 |

4. How much experience do you have with the M109/M109A1?

- ☐ 0-3 Months 1
- ☐ 3-12 Months 2 4
- ☐ Over 1 Year 7 4

5. What is your job?

_______________________________

6. The following questions ask you to agree or disagree with a statement about your training. You may circle any number from 1 (disagree strongly) to 8 (agree strongly) which reflects how you feel about the statement.

*(Circle One.)*

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| a. | I have learned a lot from field training. | | | | 2 | | 3 | | | 4 | |
| | | Disagree Strongly | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Agree Strongly |
| | | | 1 | | | 1 | 1 | 4 | 1 | 1 | |
| b. | Field training means live fire. | | 4 | 1 | 2 | . | | | | 2 | |
| | | Disagree Strongly | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Agree Strongly |
| | | | 3 | 1 | 2 | 1 | | 1 | | 1 | |
| c. | Field training means hurry up & wait. | | 2 | | 1 | | | 2 | 1 | 3 | |
| | | Disagree Strongly | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Agree Strongly |
| | | | 2 | 1 | 1 | | 1 | 1 | 1 | 2 | |
| d. | My most recent field training was exciting. | | 3 | 1 | 1 | 1 | 2 | | | 1 | |
| | | Disagree Strongly | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Agree Strongly |
| | | | 2 | 2 | 1 | | 1 | | 2 | 1 | |
| e. | My most recent field training was boring. | | 2 | | | 1 | 1 | 2 | | 3 | |
| | | Disagree Strongly | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Agree Strongly |
| | | | 2 | 1 | 1 | 1 | 1 | 1 | | 2 | |
| f. | I really became involved in my most recent field training. | | 1 | | 1 | 2 | 2 | 1 | | 2 | |
| | | Disagree Strongly | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Agree Strongly |
| | | | 1 | | 1 | 1 | 2 | 1 | 2 | 1 | |
| g. | Dry firing exercises are always a waste of time. | | 3 | | | | | 1 | | 5 | |
| | | Disagree Strongly | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Agree Strongly |
| | | | 2 | | | | 2 | 3 | | 2 | |

If you are filling out this questionnaire for the first time, STOP HERE. If you have just finished Artillery Engagement Simulation Training, answer the rest of the questions.

7. What duty position(s) did you hold during these exercises?

- ☐ a. Cannoneer
- ☐ b. Loader
- ☐ c. Gunner
- ☐ d. Communications
- ☐ e. Fuze Setter
- ☐ f. Charge Cutter
- ☐ g. Chief of Section

8. Did the Controllers slow the firing battery's performance?

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| A great deal | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Not at all |
| | | | 1 | 1 | | 1 | 3 | 3 | |

9. Did the Controllers slow your crew's performance?

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| A great deal | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Not at all |
| | | | | | | 2 | | 7 | |

10. Did the Controllers interfere with the performance of your job?

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| A great deal | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Not at all |
| | | | | | | 1 | 1 | 7 | |

11. How accurate was the Controllers' reporting of the Gun Data?

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Very poor | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Very good |
| | | | | 1 | | 2 | | 6 | |

12. Did you receive any information on the accuracy of the Battery's fire?

- ☐ a. Yes
- ☐ b. No (Skip the next question.)

13. Did the information on the accuracy of battery's fire make the training any more interesting to you compared to other non-firing exercises?

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Not at all | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | A great deal |
| | | | | | 2 | 2 | 2 | 1 | |

14. Do you have any additional comments about your experiences in this training? Write them below: (grammer and spelling corretted)

o I don't like artillery or combat MOS, period.

o I learned a lot.

o This training added a certain amount of realism to a dry firing exercise.

o A damn good exercise.

Thank you for your cooperation.

INCLOSURE C

Post Test, C/S, Gunners and AG's

ENGAGEMENT SIMULATION ARTILLERY QUESTIONNAIRE

GUN BATTERY PERSONNEL

Instructions: The purpose of this questionnaire is to find out how you feel about training in the Field Artillery. It will help us to improve the program so that you can get more out of your field training. We will not attempt to identify you or your unit and the information you provide will be used for research purposes only. Your participation in filling out this questionnaire is voluntary. We appreciate your honest answers.

1. What is your paygrade? *(Circle one.)*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5 | 1 | 2 | 6 | 3 | | | |
| E-1 | E-2 | E-3 | E-4 | E-5 | E-6 | E-7 | E-8 |

2. What is your current MOS?

____________________________________

3. How many years/months have you been in your current MOS?

______/______ *Years* *Months*

Min 0/3
Ave 2/3
Max 5/2

4. How much experience do you have with the M109/M109A1?

- ☐ 0-3 Months 4
- ☐ 3-12 Months 6
- ☐ Over 1 Year 7

5. What is your job?

____________________________________

6. The following questions ask you to agree or disagree with a statement about your training. You may circle any number from 1 (disagree strongly) to 8 (agree strongly) which reflects how you feel about the statement.

*(Circle One.)*

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| a. | I have learned a lot from field training. | Disagree | 1 | | 1 | 2 | 2 | 5 | 1 | 5 | Agree |
| | | Strongly | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Strongly |
| b. | Field training means live fire. | Disagree | 6 | 1 | 3 | 3 | | 1 | | 3 | Agree |
| | | Strongly | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Strongly |
| c. | Field training means hurry up & wait. | Disagree | 5 | 1 | 1 | | 4 | 1 | 2 | 3 | Agree |
| | | Strongly | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Strongly |
| d. | My most recent field training was exciting. | Disagree | 3 | 2 | 1 | 3 | 2 | 1 | 2 | 3 | Agree |
| | | Strongly | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Strongly |
| e. | My most recent field training was boring. | Disagree | 4 | 1 | 2 | 3 | 4 | 1 | | 2 | Agree |
| | | Strongly | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Strongly |
| f. | I really became involved in my most recent field training. | Disagree | 1 | | 2 | 1 | 4 | 1 | 4 | 4 | Agree |
| | | Strongly | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Strongly |
| g. | Dry firing exercises are always a waste of time. | Disagree | 6 | | 1 | 3 | 2 | 3 | | 2 | Agree |
| | | Strongly | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Strongly |

If you are filling out this questionnaire for the first time, STOP HERE. If you have just finished Artillery Engagement Simulation Training, answer the rest of the questions.

7. What duty position(s) did you hold during these exercises?

- ☐ a. Cannoneer
- ☐ b. Loader
- ☐ c. Gunner
- ☐ d. Communications
- ☐ e. Fuze Setter
- ☐ f. Charge Cutter
- ☐ g. Chief of Section

8. Did the Controllers slow the firing battery's performance?

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 1 | | 5 | 3 | 7 | |
| A great deal | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Not at all |

9. Did the Controllers slow your crew's performance?

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| A great | 1 | | | | 1 | 3 | | 12 | Not at |
| deal | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | all |

10. Did the Controllers interfere with the performance of your job?

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| A great | 1 | | | | | 1 | 3 | 12 | Not at |
| deal | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | all |

11. How accurate was the Controllers' reporting of the Gun Data?

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Very | | | | 1 | | 2 | 3 | 11 | Very |
| poor | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | good |

12. Did you receive any information on the accuracy of the Battery's fire?

☐ a. Yes
☐ b. No (Skip the next question.)

13. Did the information on the accuracy of battery's fire make the training any more interesting to you compared to other non-firing exercises?

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Not at | | 1 | | | 3 | 4 | 3 | 4 | A great |
| all | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | deal |

14. Do you have any additional comments about your experiences in this training? Write them below: (grammar and spelling corrected)

- Any field exercise gives you more knowledge of your job.
- If anything can be done to improve field training, I'm for it.
- I generally enjoy the field.
- It was educational.

Thank you for your cooperation.

- I don't like artillery or combat MOS, period.
- This training added a certain amount of realism to a dry firing exercise.
- A damn good exercise.
- I learned a lot.
- I learned to be a gunner and in the position to take the gunners spot. It taught me a great deal and I am happy with the training.

**INCLOSURE D**

ENGAGEMENT SIMULATION ARTILLERY QUESTIONNAIRE
FDC PERSONNEL

Instructions: The purpose of this questionnaire is to find out how you feel about training in the Field Artillery. It will help us to improve the program so that you can get more out of your field training. We will not attempt to identify you or your unit and the information you provide will be used for research purposes only. Your participation in filling out this questionnaire is voluntary. We appreciate your honest answers.

1, What is your paygrade? *(Circle one.)*

| E-1 | E-2 | E-3 | E-4 | E-5 | E-6 | E-7 | E-8 |
|---|---|---|---|---|---|---|---|
| | | 3 | 1 | | 1 | | |
| | | 3 | 1 | | 1 | | |

2. What is your current MOS?

__________________________________

3. How many years/months have you been in your current MOS?

_____/_____
*Years* *Months*

Min 1/3
Ave 2/5
Max 5/11

4. How much experience do you have with the M109/M109A1?

- ☐ 0-3 Months 1 1
- ☐ 3-12 Months 1 0
- ☐ Over 1 Year 3 4

5. What is your job?

__________________________________

6. **The following questions ask you to agree or disagree with a statement about your training. You may circle any number from 1 (disagree strongly) to 8 (agree strongly) which reflects how you feel about the statement.**

*(Circle One.)*

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| a. | I have learned a lot from field training. | | 1 | | | 2 | 1 | | | 1 | |
| | | Disagree Strongly | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 88 | Agree Strongly |
| | | | 2 | | | 1 | | 1 | | 1 | |
| b. | Field training means live fire. | | 1 | 1 | 1 | | | 2 | | | |
| | | Disagree Strongly | 1 | 2 | 3 | 4. | 5 | 6 | 7 | 8 | Agree Strongly |
| | | | 1 | 1 | | | | 1 | | 2 | |
| c. | Field training means hurry up & wait. | | | 1 | 1 | | | | | 3 | |
| | | Disagree Strongly | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Agree Strongly |
| | | | | 1 | 1 | | 1 | 1 | | | |
| d. | My most recent field training was exciting. | | 2 | 1 | | 2 | | | | | |
| | | Disagree Strongly | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Agree Strongly |
| | | | 2 | | 1 | | 1 | 1 | | | |
| e. | My most recent field training was boring. | | 1 | | | | | 2 | | 2 | |
| | | Disagree Strongly | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Agree Strongly |
| | | | 1 | | | | 2 | | | 2 | |
| f. | I really became involved in my most recent field training. | | 2 | | 1 | 1 | | | | 1 | |
| | | Disagree Strongly | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Agree Strongly |
| | | | 2 | | | 1 | | 1 | | 1 | |
| g. | Dry firing exercises are always a waste of time. | | 1 | | | 1 | 1 | | | 2 | |
| | | Disagree Strongly | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Agree Strongly |
| | | | 1 | | 1 | | 1 | 1 | | 1 | |

If you are filling out this questionnaire for the first time, STOP HERE. If you have just finished Artillery Engagement Simulation Training, answer the rest of the questions.

7. What duty position(s) did you hold during these exercises?

- ☐ a. Computer (GFT)
- ☐ b. Computer (FADAC)
- ☐ c. Computer (TI-59)
- ☐ d. HCO
- ☐ e. VCO
- ☐ f. RTO
- ☐ g. NCOIC

8. Did the Controllers slow the firing battery's performance?

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| A great deal | 2 | | | | 1 | 1 | | 1 | Not at all |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | |

9. Did the Controllers interfere with the performance of your job?

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | | | | | | 1 | 3 | |
| A great deal | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Not at all |

10. Did you receive any information on the accuracy of the Battery's fire?

☐ a. Yes
☐ b. No (Skip the next question.)

11. Did the information on the accuracy of battery's fire make the training any more interesting to you compared to other non-firing exercises?

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2 | | | | | 1 | 1 | 1 | |
| Not at all | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | A great deal |

12. Do you have any additional comments about your experiences in this training? Write them below:

o Dry fire is a waste of the Army's time.

o Method could be a great deal of help to Artillery.

o Not sure how to incorporate with maneuver elements. Otherwise an interesting and effective exercise.

Thank you for your cooperation.

o Got some cross training and found some bugs but useless for speed and accuracy of battery.

# APPENDIX H
# INTERVIEW GUIDES

TAB 1: FIST Members

TAB 2: Fire Markers

TAB 3: Fire Marker Control Computers

TAB 4: Gun Controllers

**TAB 1**

**INTERVIEW GUIDE**

**FIST Members**

The interviewer starts with a statement to the soldier to the following effect:

"The purpose of this interview is to get your candid opinion about what you have been doing in the last few days. Your name or unit will not be identified and your answers will not affect your military status in any way. So, please be as open, free and accurate as you can with your answers."

1. How much experience do you have as a FIST member and how proficient do you consider yourself in your duties?

2. How much experience do you have in adjusting live fire from this battery? If not from this battery, adjusting live fire in general? (If none or little, skip next question).

3. Do you think the speed and accuracy with which fires were marked in these exercises was significantly different from this battery's live fire performance? If you don't have enough experience with this battery, then compare it to what you would expect of a combat ready battery.

4. How much experience do you have with providing fire support to manuever unit commanders? (If none or little, skip next question).

5. Do you think the marking of fires in these exercises would have been acceptable, in terms of speed and accuracy, to a manuever unit commander?

6. As compared to other non firing exercises you have been on as a FIST member, do you think the way indirect fire was handled in these exercises has more, less or about the same training value for:
   a. yourself and the other FIST members?
   b. manuever commanders and troops?

7. What use did you make of the information that the civilian researcher gave you on the effect of your fire?

8. Do you have any suggestions for ways that indirect fire could be represented more effectively or more easily in non firing exercises?

## TAB 2
## INTERVIEW GUIDE
### Fire Marker

The interviewer starts with a statement to the soldier to the following effect:

"The purpose of this interview is to get your candid opinion about what you have been doing in the last few days. Your name or unit will not be identified and your answers will not affect your military status in any way. So, please be as open, free and accurate as you can with your answers."

1. How much experience do you have as a forward observer/FIST member and how proficient do you consider yourself?

2. Was the training you received from the civilian researchers:

   - ☐ a. not enough to learn duties of the controller?
   - ☐ b. adequate for your controller duties?
   - ☐ c. more than you needed?

3. What changes would you suggest in it? (How could we make clearer what we wanted you to do?)

4. Was the equipment you were given for your duties satisfactory?

5. What changes would you suggest to it?

6. Do you feel that you were able to perform the fire marker duties easily or were they difficult to perform?

7. If they were difficult, what did you find difficult about them?

8. What would you suggest to make your duties easier?

9. Considering the purpose of your fire marking duties (Interviewer: Ask him to state that purpose to be sure he understands it correctly), do you think any of them were unnecessary? Which?

10. Do you think that performing your fire marking duties:

- ☐ a. had a lot of training value to you in your MOS?
- ☐ b. had some training value to you in your MOS?
- ☐ c. had no training value to you in your MOS?

11. Concerning the effect of these exercises on your map reading skill, do you think these exercises:

- ☐ a. improved your map reading skill?
- ☐ b. didn't make any difference to your map reading skill?
- ☐ c. degraded your map reading skill?

The soldier should be thanked for his assistance, assured of its value in the improvement of future training, and dismissed to return to his unit.

## TAB 3

## INTERVIEW GUIDE

### Fire Marker Control Computers

The interviewer starts with a statement to the soldier to the following effect:

"The purpose of this interview is to get your candid opinion about what you have béen doing in the last few days. Your name or unit will not be identified and your answers will not affect your military status in any way. So, please be as open, free and accurate as you can with your answers."

1. How much experience do you have in computing fire missions and how proficient do you consider yourself?

2. Was the training you received from the civilian researchers:

   ☐ a. not enough to learn duties of the controller?
   ☐ b. adequate for your controller duties?
   ☐ c. more than you needed?

3. What changes would you suggest in it? (How could we make clearer what we wanted you to do?)

4. Was the equipment you were given for your controller duties satisfactory?

5. What changes would you suggest to it?

6. Do you feel that you were able to perform the controller duties easily or were they difficult to perform?

7. If they were difficult, what did you find difficult about them?

8. What would you suggest to make your duties easier?

9. Considering the purpose of your controller duties (Interviewer: Ask him to state that purpose to be sure he understands it correctly), do you think any of them were unnecessary? Which?

10. Do you think that performing your controller duties:

- ☐ a. had a lot of training value to you in your MOS?
- ☐ b. had some training value to you in your MOS?
- ☐ c. had no training value to you in your MOS?

The soldier should be thanked for his assistance, assured of its value in the improvement of future training, and dismissed to return to his unit.

## TAB 4 4
## INTERVIEW GUIDE
### Gun Controller

The interviewer starts with a statement to the soldier to the following effect:

"The purpose of this interview is to get your candid opinion about what you have been doing in the last few days. Your name or unit will not be identified and your answers will not affect your military status in any way. So, please be as open, free and accurate as you can with your answers."

1. How much experience do you have as a cannoneer on this weapon and how proficient do you consider yourself?

2. Was the training you received from the civilian researchers:

   ☐ a. not enough to learn duties of the controller?
   ☐ b. adequate for your controller duties?
   ☐ c. more than you needed?

3. What changes would you suggest in it? (How could we make clearer what we wanted you to do?)

4. Was the equipment you were given for your controller duties satisfactory?

5. What changes would you suggest to it?

6. Do you feel that you were able to perform the controller duties easily or were they difficult to perform?

7. If they were difficult, what did you find difficult about them?

8. What would you suggest to make your duties easier?

9. Considering the purpose of your controller duties (Interviewer: Ask him to state that purpose to be sure he understands it correctly), do you think any of them were unnecessary? Which?

10. Do you think that performing your controller duties:

- ☐ a. had a lot of training value to you in your MOS?
- ☐ b. had some training value to you in your MOS?
- ☐ c. had no training value to you in your MOS?

11. Do you think your activities interfered with or degraded the gun crew's performance?

12. If there was an effect on the gun crew due to your activities, what was it?

The soldier should be thanked for his assistance, assured of its value in the improvement of future training, and dismissed to return to his unit.

# APPENDIX I

## OPERATIONAL OBSERVATIONS

The Control System was initially established during a deliberate occupation of position and its set-up and communications were checked out in the course of the training phase. Following the 8th mission the battery displaced tactically, but not by echelon, to a second firing position. The FMCC displaced with the battery FDC. In both sites it was established about 100 meters from the FDC and from the gun line. The only significant problem encountered was in disestablishing and re-establishing the gun controller wire net. This was a duplicate of the battery firing hot loop except that it terminated as the FMCC rather than the FDC and did not include the aiming circle. It was installed and picked up by the battery, but had a lower priority than their firing loop. This resulted in it being picked up first and put down last. Missions therefore could not be run during two periods of about 10 to 20 minutes each when the battery was otherwise ready to fire.

Initial planning for the Control System did not include a line between the FMCC and the FDC. The amount of coordination to insure effective fire marking and provide training feedback to the battery was soon found to be such as to require one. Initially it was essential to insure that the FMCC chart and calculators were set up with the same data as used in the FDC. The FMCC then provided the FDC a set of registration data. As an aid to tracking down and correcting errors, it became a practice of the FDC and FMCC chiefs to call each other when it appeared that an error might have been made (through this practice never interfered with the fires being marked as fired).

A very appreciable delay resulted due to a communications break in the gun controllers loop and the controller's lack of training in communication procedures. He read the data into an inoperative telephone and attached no significance to the fact that he heard no read-back or acknowledgement. It was not until a member of the FMCC came up to the gun that he realized he had no communications.

Calculator operation in the FMCC was interrupted for a period of about five minutes. This occurred when the engine of the M577 was started. The calculators were connected to the vehicle's power system through their transformers and a 110V/24 AC/DC

converter. The power fluctuation evidently changed the parameters in the calculators, causing them to give logical appearing but completely wrong solutions. After reinitializing, no further problems were experienced, provided the calculator transformers were unplugged before starting the vehicle engine. (When this was done the calculators continued to operate on their internal batteries.)

The Forward Area Researcher had no difficulty in keeping the fire marker positioned at reference points from which they could readily support the action, though he did have to move each team at least once each day. The FMCC had no difficulty in keeping itself informed as to what reference point each fire marker team was on. They did not, however, always select the best team, due to having not initially developed procedures to identify the closest team or being unaware of details of terrain that made the closest fire marker not necessarily the best for the mission. On these occasions, the Forward Area Researcher intervened and directed the use of the other team.

## APPENDIX J

## CONCEPTS FOR CONTINUED ENHANCEMENT OF INDIRECT FIRE SIMULATION AND TRAINING IN ENGAGEMENT SIMULATION EXERCISES

HSR is presently conducting research that is expected to lead to the incorporation of the firing battery into engagement simulation exercises. This paper will consider what advances in the state of the art of indirect fire training will result from this research, what needs and opportunities for further enhancement of this training methodology will exist, and suggest specific near-term projects to meet these needs and take advantage of these opportunities.

Effective fire support is a product of (1) integration of fire planning with maneuver planning, (2) command, coordination and communication to execute the fire plan as the maneuver develops, and (3) performance of a series of demanding technical tasks to place the fire where it is called for. The process is one that depends on a highly interactive group of different sub-processes. To date, however, training in indirect fire has been fragmented into the sub-processes. The effective integration of the sub-processes into the overall fire support process has yet to be done in the training environment. The observers and firing battery can work together in live fire exercises which test the performance of the technical tasks. Participation by the maneuver elements insuch exercises is so seriously constrained by safety considerations that it becomes unrealistic. In most training environments there is not enough ammunition available for the amount of firing that is desirable for the unit's technical training. There is, therefore, a lot of nonfiring practice: FDC drill and "cannoneers' hop." This does provide the training but very soon becomes very tedious and, as nothing happens when the lanyard is pulled, there is no ultimate test of the artilleryman's work. The observers and fire support coordination personnel can accompany the maneuver units on FTX's, do their planning and exercise their procedures. In the absence of actual fire, there is, again, no test of the adequacy or accuracy of the work. Each of these separated modes of training precludes or degrades the practice in one or more of the sub-processes. The most serious aspect of the situation is that never are all of the sub-processes exercised together as they would have to be in combat.

The work that HSR is presently doing should provide a long step towards allowing the proper interaction of all of the fire support sub-processes in a simulation of the combat environment that has never existed before. It will cause the fires which are marked to be those

which would have been delivered by the guns. An error by the observer, the FDC team or the gun crew will be seen to be an error on the ground. If the fire plan does not support the maneuver plan, or the coordination and communication through the whole system does not permit it to be put into effect, then the fire will not be there. No umpire decision, scenario event or short range radio call will produce simulated fires which the artillery system would not actually have been able to deliver. The FDC operator and the cannoneer will know that their accuracy is the real determinant of whether or not the fire goes where the observer has called for it.

To begin a consideration of what further enhancement of indirect fire simulation is necessary and possible, a restatement should be made of what any indirect fire simulation is expected to achieve. This is (1) to permit the commanders and troops to employ and experience the best possible simulation of indirect fire, and (2) to translate that experience into more effective employment and delivery of fire. An underlying condition is that these things should be done with the minimum requirement for additional personnel and resources.

From the statement, some objectives can be developed for further work. One emerges from the fact that work to date has addressed only the delivery of high explosive shell and smoke. This is considerably less than the full range of artillery capabilities and the available simulation is therefore incomplete.

It is to be expected that future work will indicate possible improvements to the procedures that HSR is currently developing. It should be an objective of future work to find these improvements and update existing procedures accordingly.

The indirect fire simulation techniques currently in use and those being developed by HSR use only existing hardware. The capabilities of this equipment may be found to constrain future improvements, particularly in the simulation of sophisticated capabilities and in the optimization of existing techniques. While ARI does not have the mission of developing *training* hardware, it is suggested that the definition of the performance parameters needed for more effective or efficient simulation is within the ARI charter and should be considered an objective of future work.

An area of continuing need in implementing any research product is validation. HSR's current work has, within the scope of the present effort, been tested in only one

developmental test involving only field artillery troops. This is less than the complete training setting in which it must be used. Until the training value has been demonstrated in complete combined arms engagement simulation training exercises, the inferences from developmental testing that it will work remain only inferences. A future objective, therefore, must be to follow the implementation of the results of HSR's work, and, probably, of other future work, into the actual unit training environment and validate its effectiveness there.

Turning to the state of the art that will exist in engagement simulation and in artillery capabilities on completion of HSR's current work, several necessary projects immediately present themselves. As noted previously, the indirect fire capability is limited to high explosive shell and smoke, yet the Improved Conventional Munition (ICM) is probably the most devastating round in the inventory against unprotected troops. This round now comprises a significant part of the artillery's current ammunition load. The artillery is on the brink of deploying its first laser guided projectile, the Copperhead. This capability will change the observers' function, when guiding one of these projectiles from adjusting an area fire weapon to operating a direct fire weapon. This will present the entire artillery system with a radically different array of planning, coordination, and tactical and technical fire direction tasks. Concurrently, however, the artillery will still be executing its traditional area target, massed fire role. An engagement simulation, purporting to exercise the entire fire support function in a near-combat environment, which failed to exercise the concurrent execution of both of these tasks would be seriously deficient.

This discussion has introduced a number of areas for further work. The following sections present justification and descriptions of the required work for specific projects.

### Incorporation of Improved Conventional Munition (ICM) in Engagement Simulation Training Exercises

The Improved Conventional Munition (ICM) is a projectile which, at a considerable altitude above the target, disperses a large number of small submunitions to cover a large area. Although it proved its effectiveness in Viet Nam and has been in the inventory of artillery ammunition for a number of years, techniques have never been devised for simulating its effect in engagement simulation. While engagement simulation was principally a squad and platoon training technique this was logical. Due to its large area of coverage and the probability of some

residual dud submunitions, the decision to use it is usually made at company or battalion level. With the introduction of MILES, however, the echelons of command and staff which make the decision to employ ICM are brought into the exercise. Exercises to train these commanders and staffs must therefore afford them the opportunity to employ and experience the effects of these munitions.

The research that needs to be conducted consists of:

- Devising a set of procedures, similar to those that are being developed for conventional fires by HSR's current work, by which controllers can determine from a set of firing data the center and the boundaries of the pattern of the dispersed submunitions.

- Developing criteria for assessing casualty effects, including those due to residual dud submunitions, and procedures for marking the affected area, communicating the casualty criteria to the controllers and assessing the casualties.

- Documenting the methodology in form suitable for publication as training literature or amendments to training literature.

Incorporation of Copperhead in MILES
Training Exercises

The laser guided 155mm shell, the Copperhead, used with the Ground Laser Locator Designator (GLLD), the Laser Target Designator (LTD), or the Modular Universal Laser Element (MULE), will be much more than just another round of artillery ammunition. It will place the artillery in an entirely new and radically different role on the battlefield. Traditionally, the artillery's usual mission has been to deliver area fires, i.e., to place a number of projectiles in an area containing a number of targets. To use one cannon to destroy one target has been a relatively rare and difficult task, usually better done by direct fire weapons. The fielding of the Copperhead and the various laser designators will make this a routine mode of employment, yet one that must be carried on concurrently with the traditional massed fire role.

Employment of the Copperhead will require new skills of the FIST members, new lines of coordination, and new procedures in both tactical and technical fire direction. The entire system, from the FIST to the FDC to the firing battery, will be confronted with the need to exercise these skills and procedures without degrading ongoing area fire missions.

If truly effective use of the Copperhead in battle is to be obtained, it must be exercised in training in the total context of the activities that will be going on concurrently in the battle. Only in the MILES exercise does that training environment exist.

The research that needs to be done consists of:

- Devising a set of procedures, similar to those that are being developed for conventional fires by HSR's current work, by which controllers can determine that a particular set of piece and ammunition settings would or would not have caused the Copperhead projectile to be fired into the acquisition basket for the target.

- Defining necessary changes to the personnel, procedures and equipment of the exercise control system such that the observers MILES simulator would cause a "kill" when, and only when, a projectile would have been placed in the acquisition basket and the observer would have illuminated the target until its impact.

- Identifying essential characteristics that a MILES laser designator must have, working with the equipment contractor to modify a surrogate using a TOW or Dragon MILES tracker assembly, less the ATWESS feature.

- Conducting a test to demonstrate the methodology.

- Documenting the methodology in form suitable for publication as training literature or amendments to training literature.

### Adaptation of Artillery Verification Program to Mortars

One of the essential steps in incorporating indirect fire units into engagement simulation exercises is to determine where the projectile would have impacted the data set on the piece and ammunition at the time of simulated firing. A method of doing this for mortar fire units using a plotting board and firing tables has been published.[1] However, subsequent to that research, techniques have been devised for using a hand held programmable calculator as a fire direction tool for both artillery and mortars and plans initiated to issue these calculators

[1] Sevilla, *Indirect Fire Simulation*, ARI Research Product 79-3, January 1979.

(Texas Instrument model T1-59) to fire units throughout the Army. A program has also been written for these calculators when used with low angle artillery fire for determining the point of impact in an engagement simulation exercise. Experimentation with the use of the calculator and the use of the firing chart and GFT to make this determination has shown that the calculator method is faster. It has been found that it is well within the capability of anyone who can use the chart and GFT method. After initialization of the calculator it can even be used by personnel with no fire direction training; i.e., who could not use the chart and GFT method. Adapting the program to mortars is considered feasible and will require the following specific work:

- Modify the Artillery Verification Program for the Model T1-59 Hand Held Programmable Calculator so that, given the charge, elevation and deflection of a 60mm, 81mm, or 107mm mortar firing HE shell, personnel of the fire unit can calculate the point of impact of the shell.
- Conduct the necessary experimentation to demonstrate:
  - that conventional fire direction solutions (i.e., charge, deflection and elevation to hit a particular location) agree within a radial error of 50 meters with the Mortar Verification Program (i.e., coordinates of the location that would be hit by that data).
  - that the calculator program can be used by mortar fire unit personnel after not to exceed three hours of training;
- Document the research as follows:
  - A research report fully documenting the program and describing the supporting experimentation.
  - User instructions in training circular format.

**Employment of Engagement Simulation in Artillery Battery Defense Exercises**

Prior to the introduction of engagement simulation, maneuver unit FTX's were necessarily driven by a scenario and outcomes were determined by umpire judgement. The individual soldier tended to feel that what he did as an individual had little to do with the outcome, either for his unit or for him personally. The teamwork which mattered was that which the umpire saw and considered in his evaluation. Teamwork otherwise contributed little to the outcome.

All of this was dramatically changed for maneuver units when engagement simulation was introduced. The soldier killed or was killed as a direct result of what he did and the unit won or lost as a result of the performance of every fire team or weapon crew in it. The early engagement simulation techniques, REALTRAIN and SCOPES were not, however, extended to artillery battery defense exercises. These methods, simulating only the individual and automatic weapons of the battery, would have presented an incomplete simulation of the battery defense situation. One of the most significant defense resources of a battery is the suppressive effect of its big guns. Since SCOPES and REALTRAIN do not directly simulate suppression, the battery would in such exercises have been unrealistically vulnerable. Thus, battery defense exercises have continued to exhibit the faults that were typical of the classic FTX.

MILES does simulate the suppressive effect of the direct fire weapons for which it has been developed. The fact that a training device that simulates suppression is coming into the inventory completes the engagement simulation capabilities necessary to use the methodology in battery defense exercises. MILES equipment has been developed for all of the battery weapons except the artillery pieces. These, in the direct support artillery units, are similar in lethality to maneuver unit weapons for which MILES sets have been or may in the future be developed. The possibility of using existing or presently planned MILES equipment is therefore a promising one. The specific work that needs to be done is to:

- Devise a methodology for conducting a MILES exercise for an artillery battery defending itself against ground attack. A part of this methodology would be an inventory of the MILES equipment requirements of the battery. For weapons that do not have specific MILES simulation, the work should define the range of performance parameter of the MILES equipment within which it is possible to implement the methodology.

- Investigate the relevant performance parameter of existing or projected MILES equipment to identify candidates to satisfy unfulfilled needs for MILES equipment for the firing battery.

- Prepare recommendations as to artillery MILES needs which can be:

  – met using existing or projected equipment;

  – met with modification to the equipment;

  – cannot reasonably be met with any existing or projected MILES equipment.

- Assuming that at least one calibers' needs can be satisfied with an existing set, plan and conduct a field test to demonstrate the methodology.

- Document the methodology as follows:

  – A research report describing the entire research effort, including recommendations for equipment modification or development.

  – Instructions for implementing the methodology, in training circular format, for those calibers for which equipment is presently available.

### Validation of Artillery Engagement Simulation Methodology in the Unit Training Environment

The last objective, validation and continued evaluation of the contribution of engagement simulation to indirect fire training involves two distinct criteria. One is whether or not training is provided to the maneuver unit commander and fire support coordination personnel in the effective use of indirect fire. The other is whether or not training is provided to the indirect fire personnel in the effective delivery of the fire. A necessary condition to eitner of these is the ability of the training manager, trainer and control system personnel to make the engagement simulation work.

This objective is of more urgency in indirect fire than in other aspects of engagement simulation for two reasons. First, the procedures for incorporating the fire unit into the

exercise are new and there is as yet little experience with them in a training environment. The only such observations, in fact, are those of a single mortar section in the Armored Cavalry test in November 1977 and of an artillery battery at in October 1979. By contrast, the MILES methodology will have been evaluated in TIE, the MILES OT II and the Battalion ES/ARTEP test. The second reason, particularly applicable to the question of control system performance, is the complete dependence of the indirect fire simulation on human performance. At the heart of the MILES simulation is a piece of automatic equipment. The humans provide the environment in which it can be used to cause learning, but they don't also have to provide the actual simulation. In indirect fire simulation, they must also do that.

The questions of the quality of the control system and effectiveness of the training are particularly important at the time when both MILES and the procedures for incorporating the fire unit into the exercise are first being introduced to the Army. While responsibility for managing this introduction belongs to TRADOC, there are, it is suggested, some things during that period that are best done under ARI cognizance. These are the things which relate to the adequacy of the basic method. TRADOC has the task of ensuring adequate execution; PM-TRADE has the task of ensuring adequate equipment. It is ARI that can verify the adequacy of the method of such things as the selection, training or duties of control system personnel, perceptions by the troops, or their acceptance of the method. While this comment is general to the entire engagement simulation field, it is as previously observed, more urgent for the indirect fire methodology because of the vastly lesser experience with it.

The work recommended for validation of the indirect fire methodology is to:

- plan and conduct a "turnkey" test of the entire indirect fire methodology, including both mortar and artillery fire units with the supported maneuver units in a home station ES training environment;
- observe introductory exercises (e.g., Mobile Training Team, Training Center courses) employing the entire indirect fire methodology with the maneuver unit; and,
- prepare a research report either validating the existing methodology or presenting recommendations as to revised training structure, control system organization, duties or equipment, selection criteria or training programs.

# APPENDIX K

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